# Iron AND Steel ENGINEER

NGINEERING SERVICE
THE IRON AND STEEL
DUSTRY SINCE 1907

O EMPIRE BUILDING
CHNOLOGY DEPT.

FEBRUARY, 1946

PITTSBURGH, PA.

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DETROIT

WHATEVER THE SHAPE...
for less cost per ton
of steel rolled,
rely on...
PITTSBURGH ROLLS
P.R.W.
PITTSBURGH ROLLS
Division of Rare-Knox Company
PITTSBURGH, PA.

# The time it takes when controls are scattered...

## is saved by UNITROL

(Reg. U. S. Pat. Office)

● And with UNITROL you gain needed speed of installation and change . . . orderly factory arrangement . . . a modern motor control housing that economizes space, eliminates floor and wall preparation, and extorts no penalties in cost. A 36-page brochure is yours for the asking. CUTLER-HAMMER, Inc., 1269 St. Paul Ave., Milwaukee 1, Wis. *Associate:* Canadian Cutler-Hammer, Ltd., Toronto, Ont.

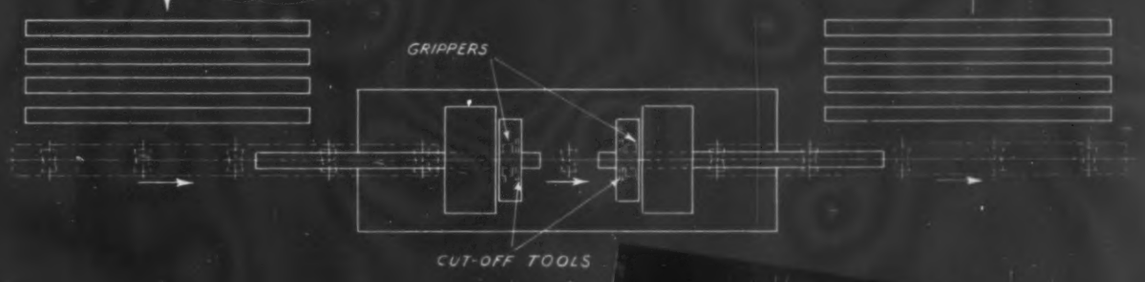
CUTLER-HAMMER
UNITROL
C-H

With UNITROL, all motor control in a factory may be housed in one compact, convenient control center.

THERE'S ALWAYS SOMETHING *NEW* AT AETNA • STANDARD

# AUTOMATIC TUBE CUTOFF-

## *with Chamfering and Reaming Tools*



This newly designed machine by Aetna-Standard puts the Cutting-Off operation on a production basis.

Two (2) machines are arranged in tandem to form a single operating unit. The tubes or pipe move in a continuous flow from the hot mill directly to the feed conveyors of the Cutoff.

Simultaneously two (2) tubes are positioned for desired crop length and a push button control initiates the automatic cutting cycle.

Two (2) ends, the front end of one tube and the back end of the other tube, are cut in the same operation. The cutting tools retract immediately and the reaming and chamfering cycle moves into action automatically. The operator can control the reaming and chamfering tools mechanically, if he desires, by a second push button control.

Aetna-Standard now has these revolutionary, new cutoff machines in operation for O. D. range of 3″ to 8⅝″ with units under construction for other sizes of seamless and welded tube and pipe.

*Here are some of the features and advantages of the new Aetna-Standard cutoff machine:*

- Continuous flow of material . . . no reversing.
- Faster cutting . . . 3 cutting tools instead of conventional 2.
- Revolving cutting tools . . . tube remains stationary.
- Only one operator required for two machines.
- Easy adjustments for tool feed and tool positions.
- Automatic cutting, chamfering, and reaming cycles.

Write for details on the new cost-cutting cutoff, a new development by Aetna-Standard Engineering Co.

**THE AETNA-STANDARD ENGINEERING COMPANY**

YOUNGSTOWN, OHIO

DESIGNERS AND BUILDERS to the Steel, Non-Ferrous and Chemical Industries.

*ASSOCIATED COMPANIES:*

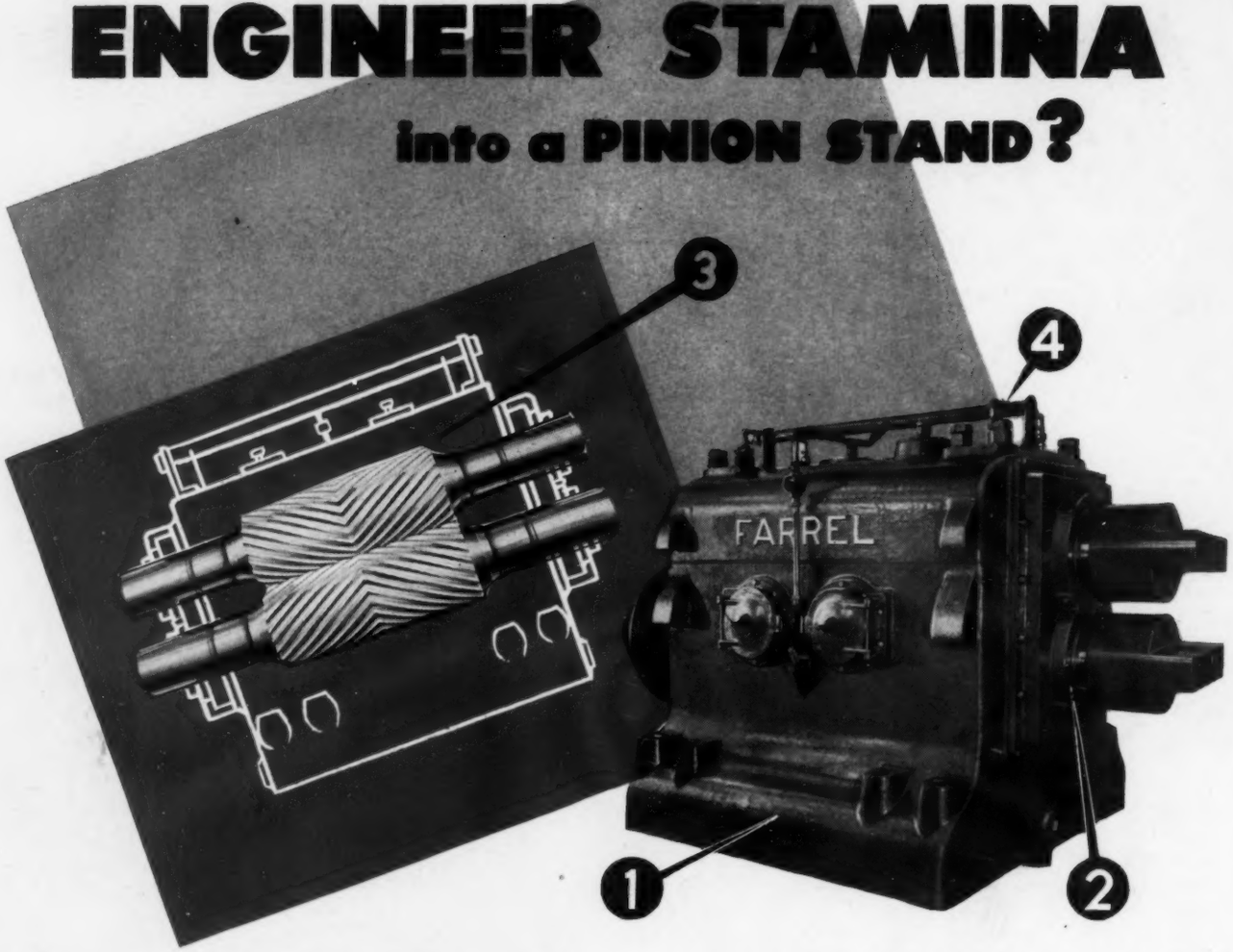
HEAD, WRIGHTSON & COMPANY, LIMITED, THORNABY-ON-TEES, ENGLAND

JOHN INGLIS COMPANY, LIMITED, TORONTO, ONTARIO, CANADA

# HOW DOES FARREL

# ENGINEER STAMINA

## into a PINION STAND?




Stamina in a Farrel pinion stand is its ability to maintain continuous high efficiency of power transmission, despite the shocks and stresses incurred during many years of rugged duty.

Farrel design gives a pinion stand this enduring efficiency by providing special protection at every vital point. These engineered-in safeguards "shockproof" the pinion stand, fortify against wear, and assure long, trouble-free service:

1. HOUSING—Meehanite, cast steel or welded steel construction, designed to bear the brunt of continued strain and stress encountered in rolling mill service and to maintain accurate alignment of the pinions.
2. BEARINGS—Babbitt-lined, steel-backed, sleeve bearings, or any approved make of anti-friction bearings—always amply proportioned for the job they have to do.
3. PINIONS—Continuous tooth herringbone, precision generated by the famous Farrel-Sykes process. The fact that the helices meet in sharp apices, instead of being separated by a center groove, provides extra strength and load-carrying capacity. Interlacing of the teeth, gradual engagement and inclined line of pressure all contribute to smooth, quiet operation and maintenance of correct tooth action throughout the life of the pinions.
4. LUBRICATION—By dip-and-splash system, or force-feed by separate motor-driven pump or from centralized lubricating system, depending on conditions or requirements.

Farrel will design and build a pinion stand to fit your particular application. Information and specifications on request.

FB-274

**FARREL-BIRMINGHAM COMPANY, INC.**
**ANSONIA, CONN.**

*Plants:* Ansonia, Derby and Stonington, Connecticut; Buffalo, New York

*Sales Offices:* Ansonia, Buffalo, New York, Pittsburgh, Akron, Los Angeles, Tulsa, Houston, Charlotte

Farrel-Birmingham

United 4-High Skin Pass Mill

# UNITED
## Skin Pass Mills

To manufacturers planning enlargement of their capacity for the production of sheet or tinplate stock, United offers immediately available designs of modern **Skin Pass Mills** or will develop entirely new designs to meet specific operational or product requirements. The cooperation and advice of United's engineers and the manufacturing capacities of our six great plants are at your service.

United 4-High, 2-Stand Tandem Skin Pass Mill

**UNITED ENGINEERING AND FOUNDRY COMPANY**

**PITTSBURGH, PENNSYLVANIA**

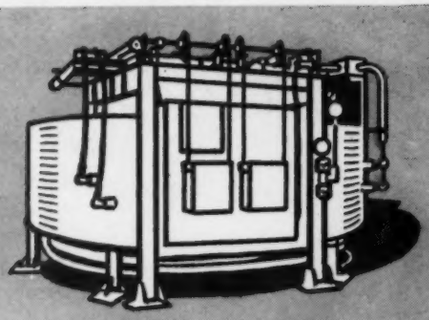
**Plants at PITTSBURGH · VANDERGRIFT · NEW CASTLE · YOUNGSTOWN · CANTON**

**Subsidiary: Adamson United Company, Akron, Ohio**

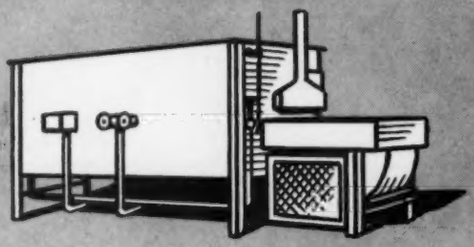
**Affiliates: Davy and United Engineering Company, Ltd., Sheffield, England**

**Dominion Engineering Works, Ltd., Montreal, P. Q., Canada**

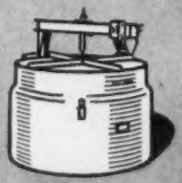
*★ The World's Largest Designers and Makers of Rolls and Rolling Mill Equipment*



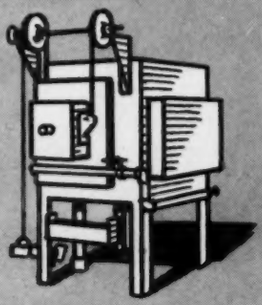
ROTARY-HEARTH FURNACE



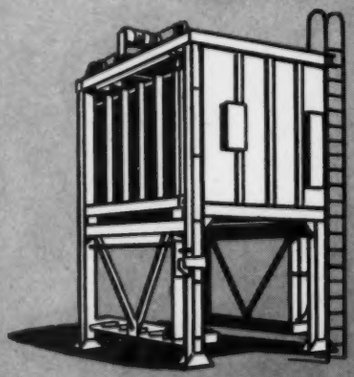
CONVEYOR FURNACE



PIT FURNACE



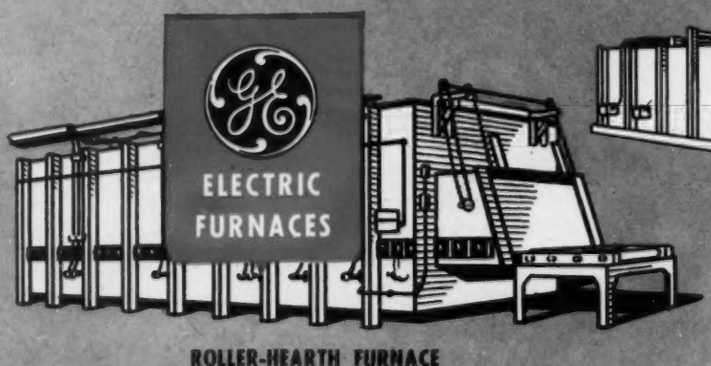
BOX FURNACE



ELEVATOR FURNACE

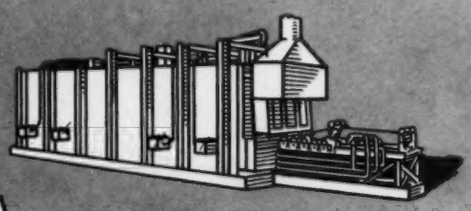
# HOW TO HEAT-TREAT HIGH-SPEED STEELS *without decarb*

1. High-speed steels of all types—moly, tungsten, or cobalt—can be heat-treated in G-E electric box furnaces without the formation of scale and with *no* decarburization. A typical installation consists of a preheat and a high-heat furnace, as installed here in an ordnance plant.

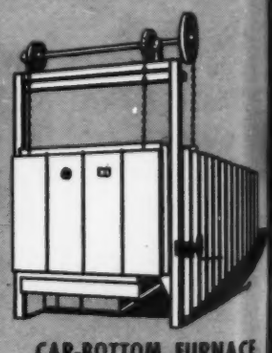


ELECTRIC FURNACES

ROLLER-HEARTH FURNACE

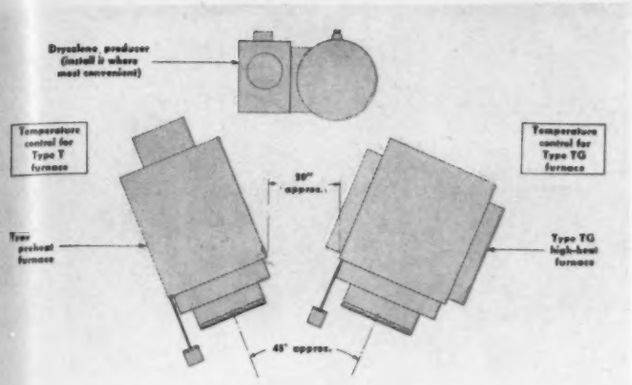


PUSHER FURNACE

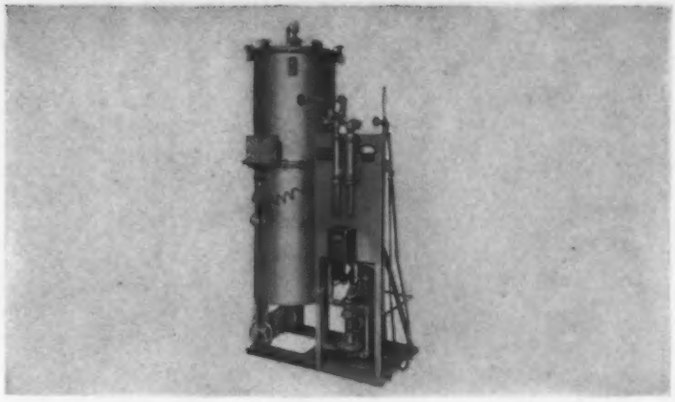


CAR-BOTTOM FURNACE

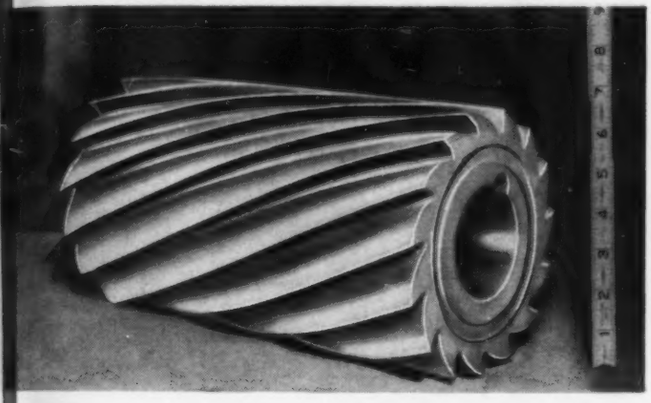
**For Practically Every Industrial Need . . . Backed by a Nationwide Engineering Service**


Drycolene producer (install it where most convenient)
Temperature control for Type T furnace
Temperature control for Type TG furnace
20" approx.
Type T preheat furnace
Type TG high-heat furnace
45° approx.

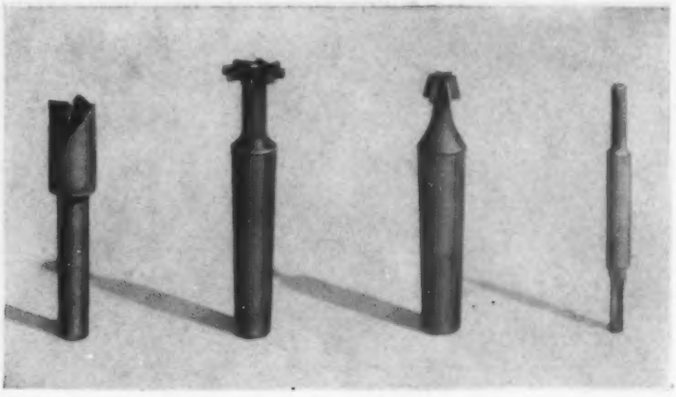
2. When the two furnaces are installed in accordance with this recommended layout, the operator, by making an easy pivot, can transfer work from the preheat furnace to the high-heat furnace without unnecessary steps. A water-quench tank can be located in front of the preheat furnace; an oil-quench tank, in front of the high-heat furnace.



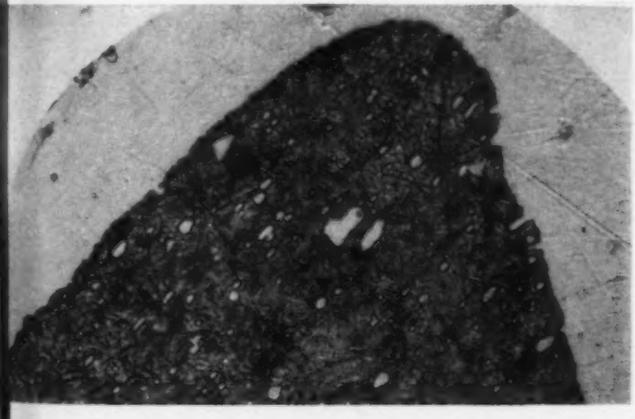
3. During the heat treatment of high-speed steel, a protective atmosphere, free of carbon dioxide and water vapor, must be introduced into the furnace to prevent oxidation and decarburization of the steel. Such an atmosphere is created by the processing of standard fuel gases and air in this specially constructed, 200-cfh, G-E drycolene producer.



4. This sturdy, slab-milling cutter of Bethlehem No. 66 high-speed steel was made to size before heat-treating. It was given a first preheat at 550 F in air, a second at 1550 F in drycolene, and a high heat at 2250 F in drycolene plus propane. There was no decarb, and edges were file hard.



5. In cutters such as these, of moly and cobalt high-speed steels, both sharp cutting edges and sharp corners must be maintained. After heat treatment in a G-E Type TG box furnace, in drycolene atmosphere, the cutters were free of scale and decarb; both cutting edges and corners were file hard.



6. The cutting edge of the moly-cobalt, high-speed tool in this photomicrograph (X-500) clearly shows the absence of decarb and the uniform distribution of carbon particles. Because the hardness extends right to the surface, no finish-grinding is necessary.

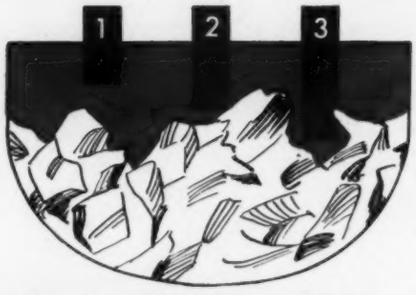
7. To advise you on an industrial heating problem, G.E. maintains heating specialists in all principal cities, plus an engineering staff qualified to recommend the *best* type of equipment for your particular purpose. For detailed recommendations, consult your nearest G-E heating specialist, or write Apparatus Dept., General Electric Company, Schenectady, N. Y.

**GENERAL ELECTRIC**

# Which of These Arc Furnace Operating Troubles Do You Have?

*HERE ARE 6 COMMON DIFFICULTIES — AND HERE'S HOW "REGULEX" CONTROL HELPS YOU CORRECT THEM*

## MELTDOWN PERIOD

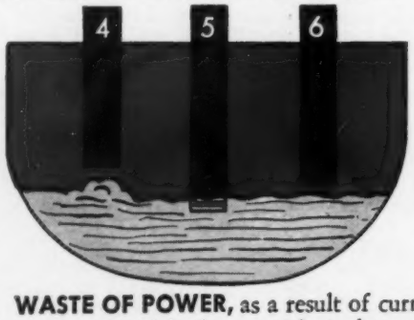



1. **REPEATED ARC INTERRUPTIONS,** due to sudden "settling" of metal. Sensitive "Regulex" generators reduce arc restrikes by continuous, accurate adjustments.

2. **INSTABILITY OF ARC,** due to inaccuracy of control for raising electrode when short circuit occurs. "Regulex" variable voltage control raises electrodes *just the right amount* — keeps arc values constant.

3. **BREAKAGE OF ELECTRODES,** caused by caving in of metal charge against electrodes. Fast-acting "Regulex" control pulls electrodes safely out of a cave-in . . . also conserves electrodes by reducing number of arc restrikes that must be made.

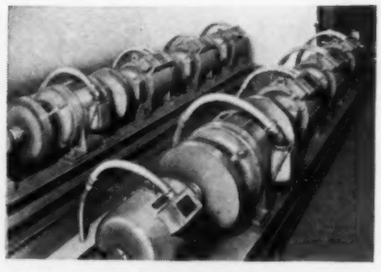
## REFINING PERIOD




4. **WASTE OF POWER,** as a result of current surges when metal boils up against electrodes. "Regulex" variable voltage control raises electrodes with acceleration proportional to deviation of arc current and voltage from normal . . . reduces power input.

5. **FREEZING OF ELECTRODES** in molten bath, due to electrode "drift" when a-c power fails. Only the "Regulex" generator set is provided with a flywheel for automatically raising electrodes upon a power failure . . . preventing electrode breakage.

6. **BURNING OF ELECTRODES** during refining period, because of using too short an arc. Accurate "Regulex" control permits use of longer arc — conserves electrodes.



## LET ACCURATE "REGULEX" CONTROL SAVE YOU MONEY

*EXTRA MELTS—Variable voltage control meets rapidly changing furnace conditions . . . often gives one or more additional melts per day.*

*LESS POWER WASTE—Elimination of wasteful current surges reduces kilowatt-hour input.*

*LONGER ELECTRODE LIFE — There's less electrode burning and breakage with quick-acting "Regulex" arc furnace control.*

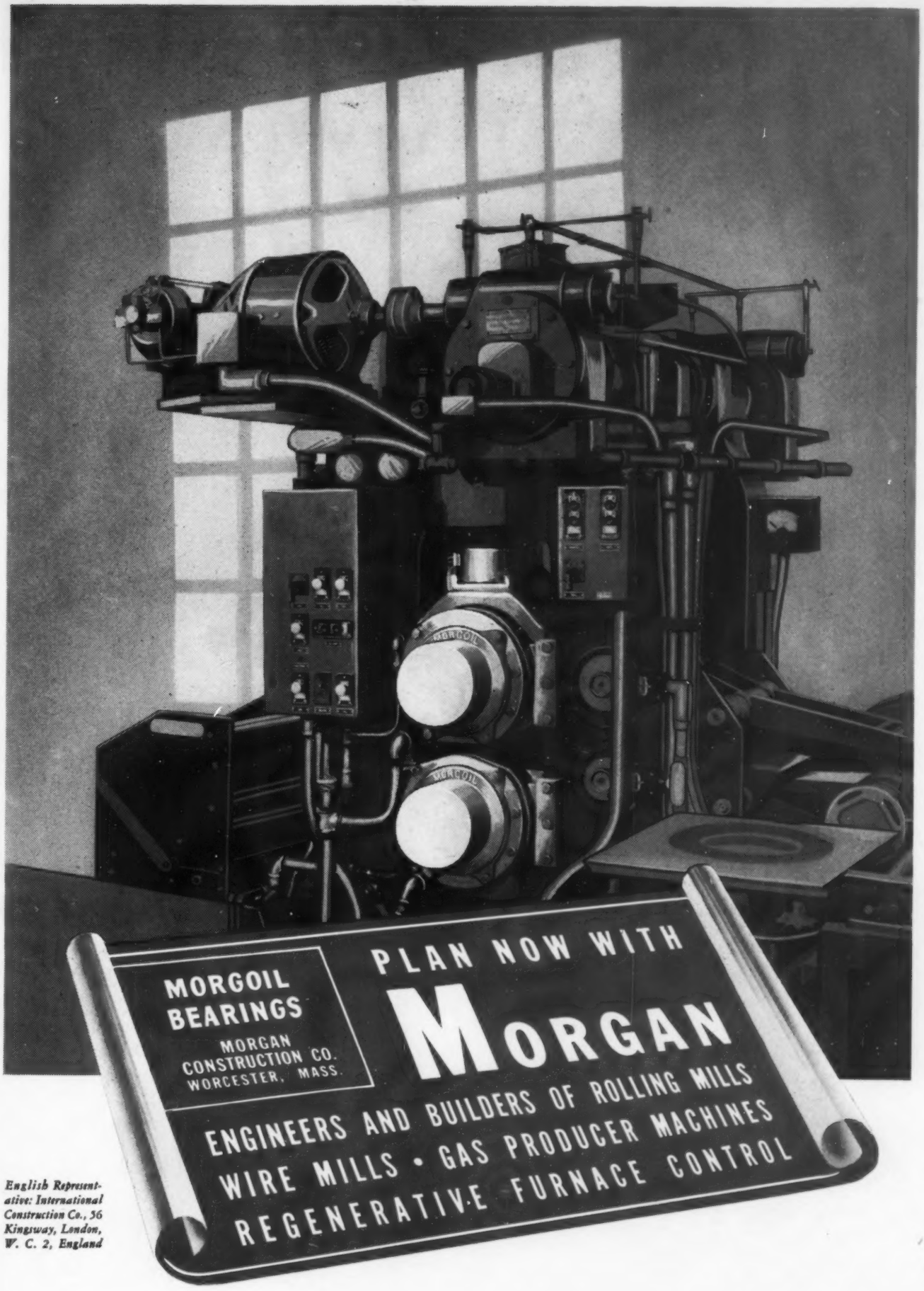
*Your arc furnace manufacturer will be glad to tell you about "Regulex" furnace control — or write directly to* ALLIS-CHALMERS MFG. CO.

# Allis-Chalmers

**MILWAUKEE 1, WIS.**

A 1938

**HEAR THE BOSTON SYMPHONY:** *Every Saturday Evening, American Broadcasting Co.*




*English Representative: International Construction Co., 56 Kingsway, London, W. C. 2, England*

# * Continuous electrolytic tin plating lines . . .

DISCHARGE END OF MESTA 42" CONTINUOUS ELECTROLYTIC TIN PLATING

# * built by MESTA

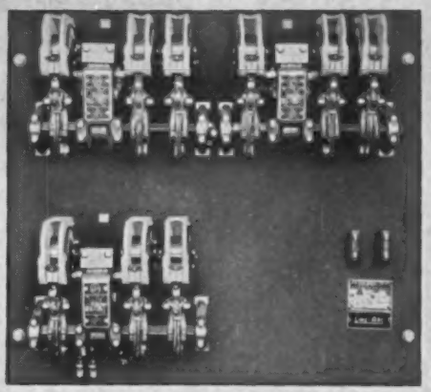
## MESTA MACHINE COMPANY

PITTSBURGH, PENNSYLVANIA

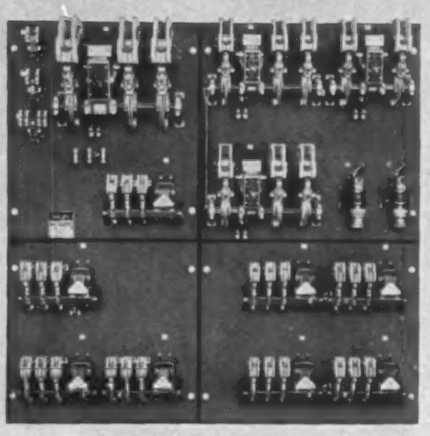
ARMY E NAVY

The Army-Navy "E" Flag with five stars flies over the Mesta Plant

# *Control* by EC&M assures high efficiency of BILLETEER



EC&M LINE-VAC Contactor Control for the Billeteer tool head and elevator drive. This unit is mounted in the cabinet on the Billeteer.



EC&M Controller for separate mounting in cabinet which controls other motions of the Billeteer.

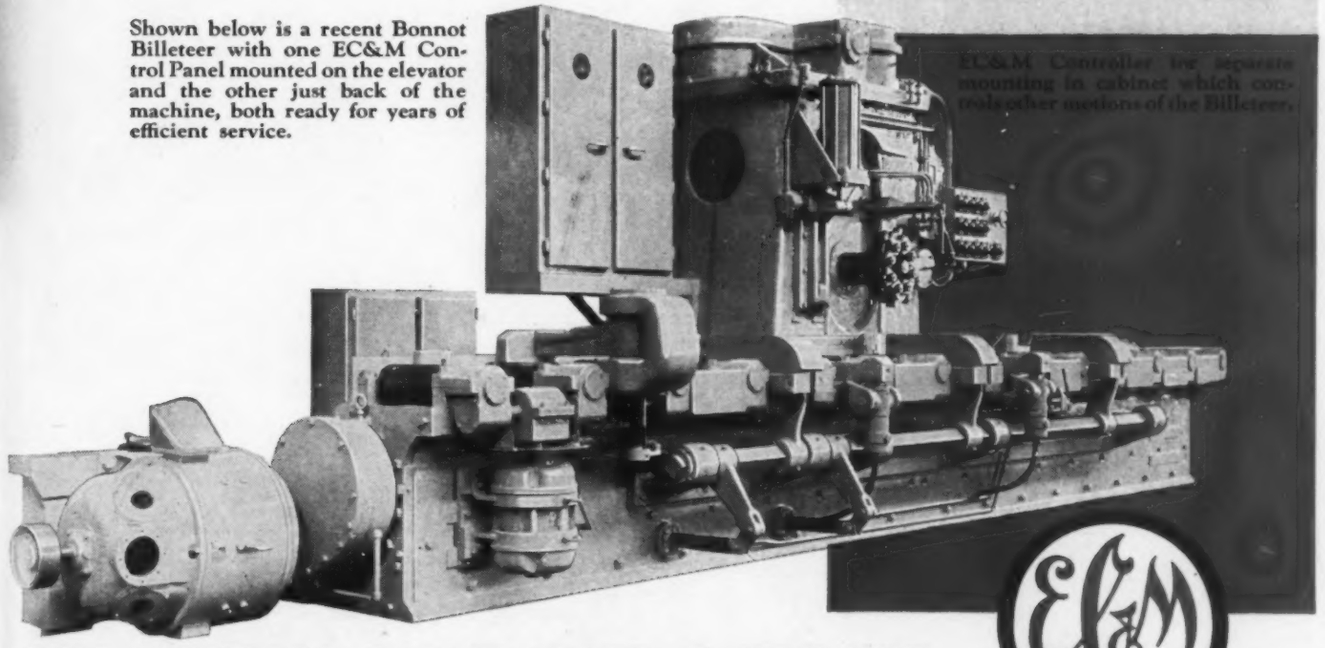
● Spotting the cutting head of the Billeteer over the seams and defects of billets is not only a continuous job but one which requires perfect dependable control of a machine that weighs 150,000 pounds.

The operator must have fingertip control of the cutting head in addition to operating the approach and runout tables and all manipulation of the billet itself.

The unit shown below was just completed for a steel company which has three other Billeteers EC&M equipped. They know the rugged, twenty-four hour a day punishment these controls must undergo.

Our nearest office will gladly supply complete details.

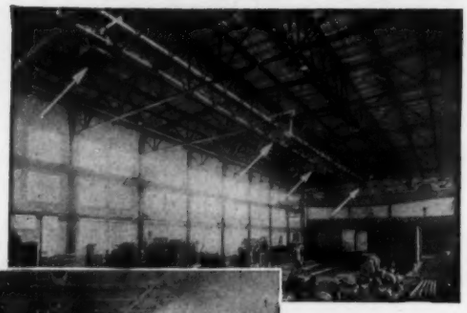
Shown below is a recent Bonnot Billeteer with one EC&M Control Panel mounted on the elevator and the other just back of the machine, both ready for years of efficient service.



**THE ELECTRIC CONTROLLER & MFG. CO.**

**2700 East 79th Street** **Cleveland 4, Ohio**

# Wing Unit Heaters Solve the Problem of the Hard-to-heat Railway Shop

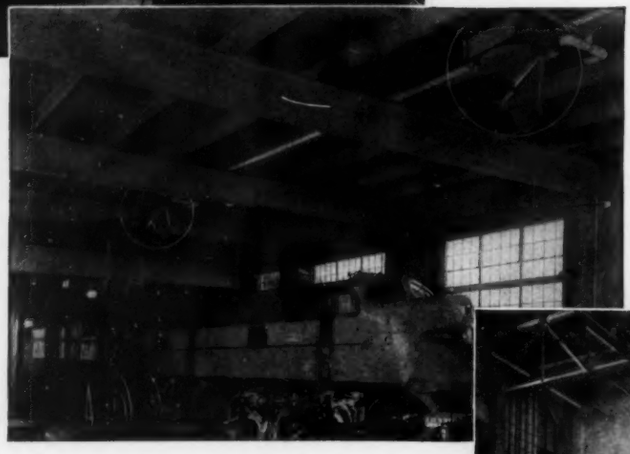


*Wing Unit Heaters in Railway Repair Shop. Chicago, Milwaukee & St. Paul R. R.*

1925

1928 *Wing Unit Heaters in Engine Shop Canadian National Railways*

Notoriously hard to heat (or, let us say, hard to keep at a comfortable temperature—for sometimes it is too hot) the average railway shop—engine house, round house or repair shop—is a problem. But WING engineers have been solving that problem ever since the invention (by WING) of the "featherweight," ceiling-suspended, downward discharge unit heater in 1922. Many railway shops, as shown in these photographs, have been equipped with WING Unit Heaters.



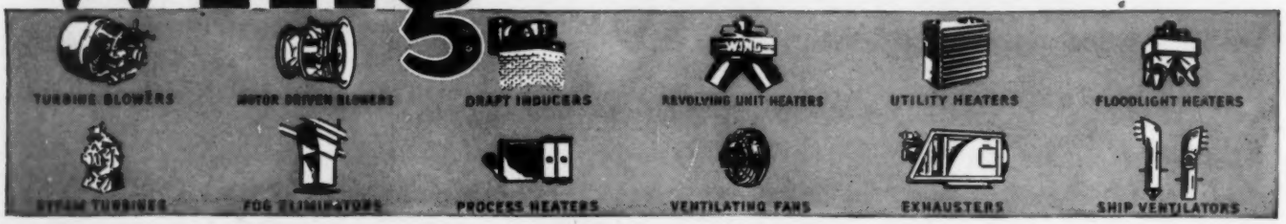
1939 *Wing Revolving Unit Heaters in Engine Shop — Chicago, Milwaukee & St. Paul R. R.*

1944 *Wing Revolving Unit Heaters in Locomotive Shop of Northern Pacific R. R.*

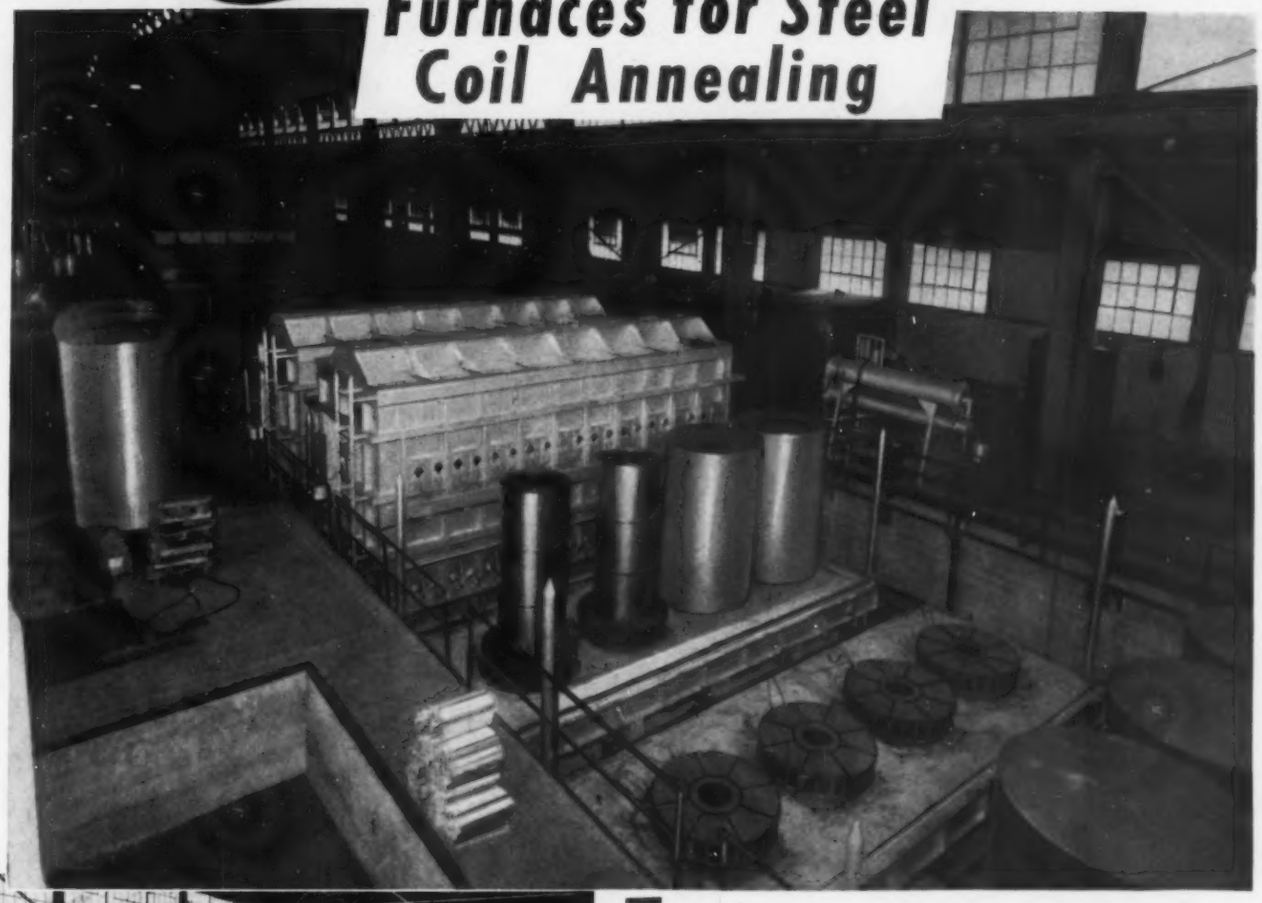
The present WING *Revolving* Unit Heater, with its more thorough distribution of the heated air, and its ability, because of the slowly revolving discharge outlets, to get under and around obstructions, into far corners and repair pits, makes it the ideal heating system for railway buildings.

**L. J. Wing Mfg. Co., 142 W. 14th St., New York 11, N. Y.**

**Wing REVOLVING UNIT HEATERS**



# WILSON Rectangular and Cylindrical Bell Type Furnaces for Steel Coil Annealing



THE Lee Wilson Engineering Company is ready for the new expansion in the strip sheet and tin plate industry.

New developments in the use of radiant tube and convection heating will increase the tons per hour yield in annealing furnaces designed for larger coil diameters and increased piling heights.

The Wilson Annealing Unit is covered by Patents Nos. 1,952,402, 2,068,477, 2,078,356, 2,081,612, 2,089,843, and other patents pending.

ENGINEERED AND CONSTRUCTED BY THE

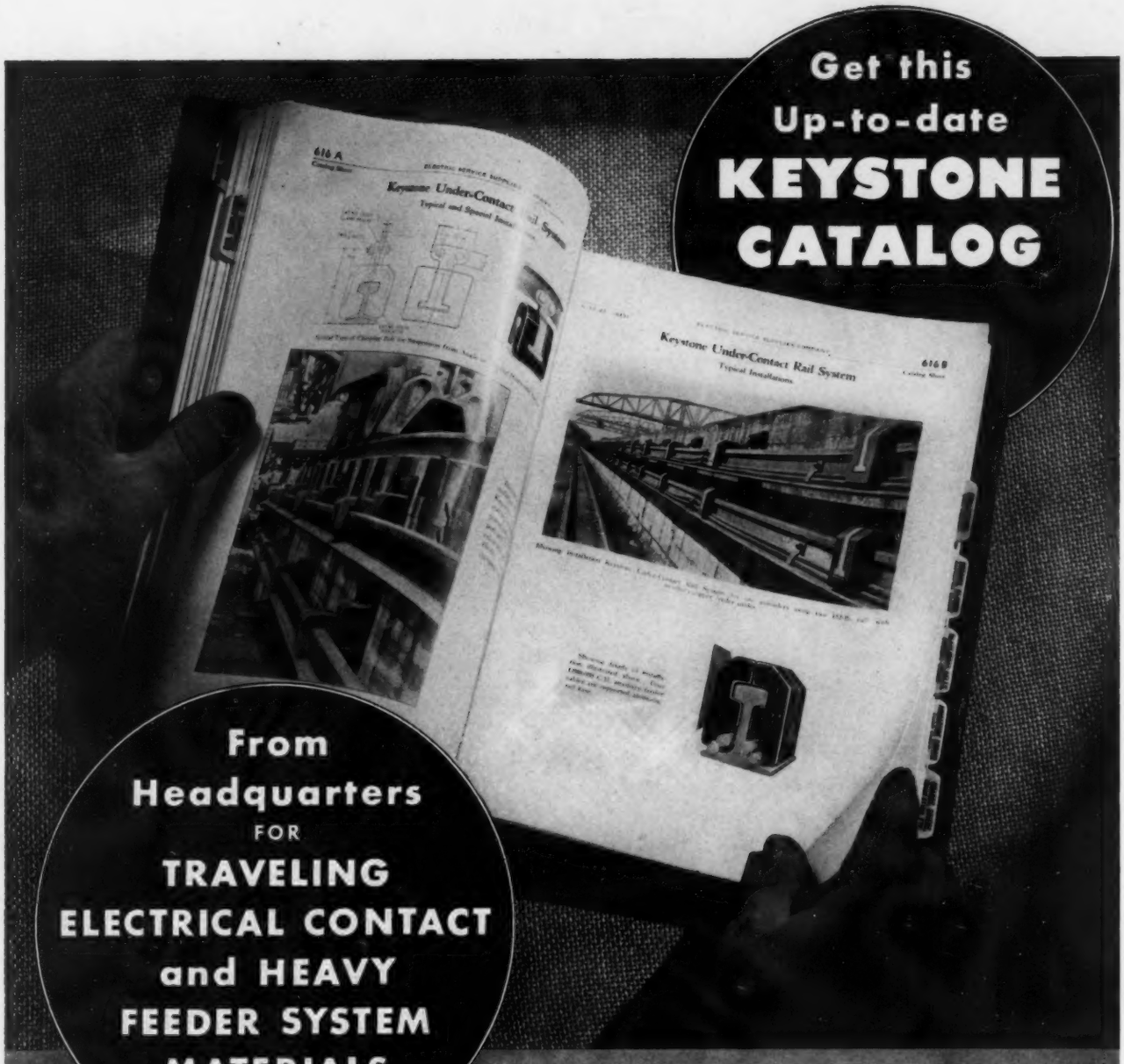
**Lee Wilson ENGINEERING Co., Inc.**

20005 West Lake Road CLEVELAND, OHIO

Telephone ACademy 4670

Sold by The WEAN ENGINEERING CO., Inc., Warren, Ohio

INDUSTRIAL FURNACES • RADIANT TUBE HEATING • HEAT TREATING PROCESSES




This catalog will help you. Contains 500 pages listing hundreds of items necessary to maintain crane runways and electrical feeder systems. Ask for catalog "Keystone Electrical Material" if you do not have it in your files.

BUY ANOTHER BOND

**ELECTRIC SERVICE MANUFACTURING CO.**

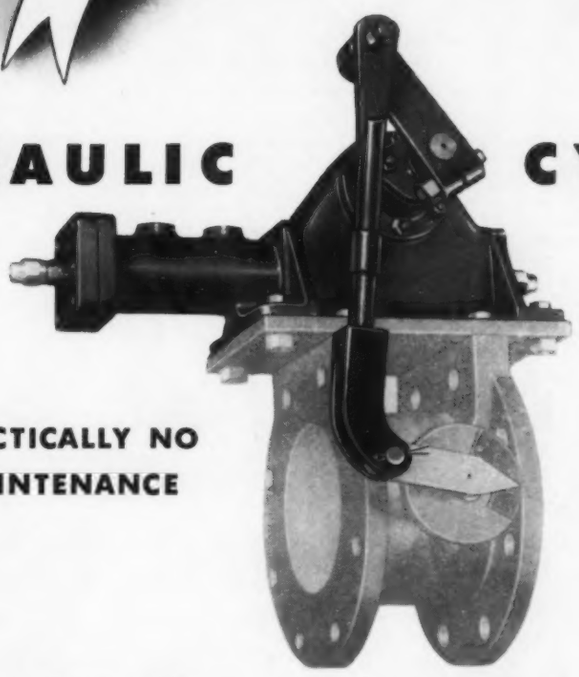
*Former Name—Electric Service Supplies Co.*

17th & CAMBRIA STREETS • PHILADELPHIA 32 • PA. • Branches in Principal Cities

# ASKANIA

CRANK-TYPE

## HYDRAULIC CYLINDERS



PRACTICALLY NO MAINTENANCE

VIRTUALLY LEAK-PROOF

*A Flexible Source of Hydraulic Power*

**The outstanding feature concerning Askania Crank-Type Cylinders which engineers talk about is that once they are installed and set, you can forget about them! That's true because these cylinders, employing a rotary shaft, are inherently more oil-tight than the reciprocating type.**

**The ground ringless pistons not only provide almost fictionless operation . . . but they also keep maintenance at an irreducible minimum.**

**Bulletin 126 describes the characteristics of Askania Crank-Type Cylinders in detail. Write for your copy today.**

**ASKANIA REGULATOR CO.**

A GENERAL PRECISION EQUIPMENT CORPORATION SUBSIDIARY

1601 S. MICHIGAN AVENUE, CHICAGO 16, ILLINOIS

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Pacific Fruit Express Company
Pacific Gas and Electric Company

Here is a partial list of companies . . . large and small . . . that have demonstrated their faith in Fluor Cooling Towers by buying them again and again. Their names speak volumes; and their buying judgment is sound because it is based on performance!

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Macmillan Petroleum Products Company
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National Carbide Corporation
National Cylinder Gas Company
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National Portland Cement Company
National Sanitary Company
National Supply Company
National Tube Company
National Zinc Company
Natural Gasoline Corporation

Pacific Lighting Corporation
Pacific Rubber and Tire Company
Pan American Petroleum Company
Panhandle Eastern Pipe Line Company
Permanente Metals Corporation
Phillips Petroleum Corporation
Pittsburgh Des Moines Steel Company
Prest-O-Lite Company, Incorporated
Procter and Gamble Manufacturing Co.
Pullman-Standard Car Manufacturing Co.
Pure Carbonic, Incorporated
Pure Oil Company

Quaker State Oil Refining Corporation

R. C. A. Manufacturing Company
Ralston Steel Car Company
Rheem Manufacturing Company
Richfield Corporation
Rio Grande Oil Company
Root Petroleum Company
Rothschild Oil Company

Scaife Company
Shell Chemical Company
Shell Development Company
Shell Oil Company

Shell Petroleum Company
Signal Oil and Gas Company
Sinclair Prairie Oil Company
Sinclair Refining Company
Skelly Oil Company
Socony-Vacuum Oil Company
Southern California Gas Company
Southern Counties Gas Company
Southern Natural Gas Company
Southern Pacific Company
Southwestern Power and Light Company
Standard Oil Company of California
Standard Oil Company of Louisiana
Standard Oil Company of New Jersey
Standard Pipeline Company
Stauffer Chemical Company
The Stearns Roger Manufacturing Co.

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Sun Oil Company
Superior Oil Company
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The Texas Company
The Texas-Louisiana Power Company
The Texas Chemical Company
Texas Gulf Power Company
Texoma Natural Gas Company
Tidewater Associated Oil Company
Todd-California Shipbuilding Corp.
Treesweet Products Company
Truscon Steel Company

Union Meat Company
Union Oil Company
Union Pacific Railroad Company
Union Potash and Chemical Company
Union Sulphur Company
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United Fuel Gas Company
United Gas Public Service Company
United States Army
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Universal Oil Company
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Warren Petroleum Corporation
Weirton Steel Company
West End Chemical Company
Western Electro Chemical Company
Western Enterprise Engine Company
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Westinghouse Electric and Mfg. Co.
West Virginia Gas Corporation
Wilmington Gasoline Company
Wilshire Oil Company
Worthington Pump and Machinery Co.

York Ice Machinery Company

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# Gear Puzzle with a Payoff for your Plant!

**Call in SOCONY-VACUUM for this Correct Lubrication Program**

- Lubrication Study of Your Entire Plant
- Recommendations to Improve Lubrication
- Lubrication Schedules and Controls
- Skilled Engineering Counsel
- Progress Reports of Benefits Obtained

GARGOYLE Lubricants

NO, this isn't an engineer's nightmare! It's our conception of the different types of gears in your plant, linked in a continuous train. Production costs . . . and profits . . . depend on efficient operation of gears like these. Each gear has its own lubrication needs.

Some are ordinary open gears. Socony-Vacuum makes a special "Black Magic" fluid to prolong their life. There's a worm gear. Socony-Vacuum has special oils that stay on despite the wiping, sliding action. There are herringbone gears, hypoids, bevels and spiral-bevels. Socony-Vacuum engineers have the products . . . and the knowledge . . . to assure scientific lubrication for every type under every condition.

The same applies to all bearings and cylinders. Socony-Vacuum's great new wartime developments, backed by 80 years' lubrication experience, are available in a Complete Lubrication Program for your plant. Insure maximum machine efficiency now with this program.

## Socony-Vacuum Oil Co., Inc.

and Affiliates: Magnolia Petroleum Company, General Petroleum Corp. of Calif.

Tune In "Information Please"—Monday Evenings, 9:30 E.S.T.—NBC

# P-G STEEL GRID *Resistors . . .* *for* HEAVY DUTY APPLICATIONS:

. . . Built for severe service conditions

. . . Protect vital electrical equipment

. . . Constant "Trouble Free" performance

. . . Quick adjustments easily made

★ ALL STEEL CONSTRUCTION
★ MICA INSULATION
★ RUGGED TERMINALS
★ PROVISION FOR EXPANSION
★ ADEQUATE VENTILATION
★ UNAFFECTED BY VIBRATION
★ MOISTURE RESISTANT
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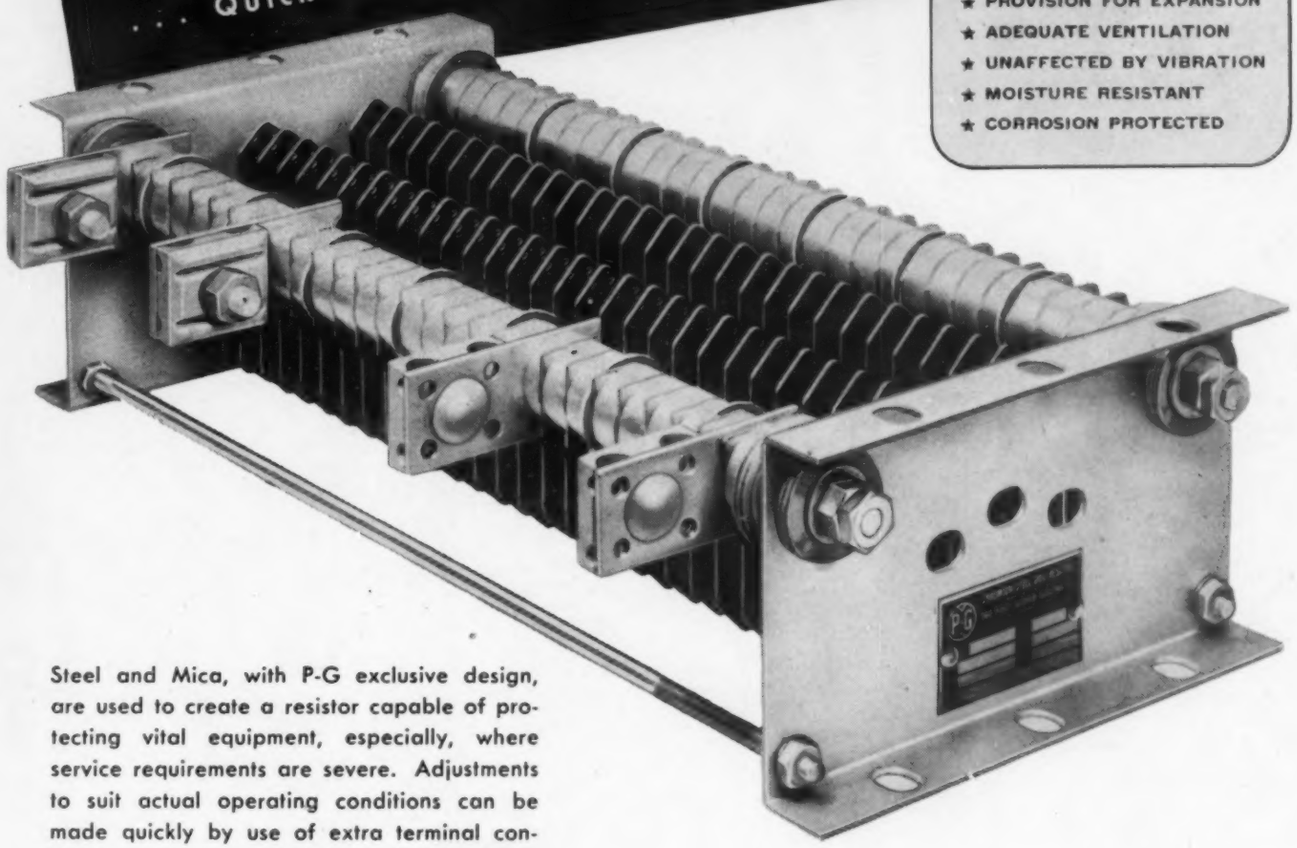


Steel and Mica, with P-G exclusive design, are used to create a resistor capable of protecting vital equipment, especially, where service requirements are severe. Adjustments to suit actual operating conditions can be made quickly by use of extra terminal connections usually available. Try P-G Resistors for constant "*Trouble Free*" performance.

**BULLETIN No. 500 . . .**
Gives detailed information . . . Copy on request.

P-G

*The Nonbreakable Steel Grid Resistor*

**THE POST-GLOVER ELECTRIC COMPANY**

• ESTABLISHED 1892 •

221 WEST THIRD STREET, CINCINNATI 2, OHIO

This modern
**light-oil** and **pure-products** plant
was recently completed by

# KOPPERS

THIS MODERN PLANT for The Colorado Fuel and Iron Corporation at Pueblo, Colorado, was built by Koppers to recover the light oil from 1,825,000 tons of coal per year and to refine this oil into products of highest purity at lowest cost.

It replaced an older plant when new Koppers-Becker Underjet coke ovens added a half million tons to the annual coal carbonizing capacity.

**KOPPERS COMPANY, INC.**

**ENGINEERING AND CONSTRUCTION DIVISION,** *PITTSBURGH 19, PA.*

# POOLE

A COPY OF CATALOG GIVING FULL DESCRIPTION AND ENGINEERING DATA SENT UPON REQUEST.

# FLEXIBLE COUPLINGS

POOLE FOUNDRY & MACHINE COMPANY WOODBERRY, BALTIMORE, MD.

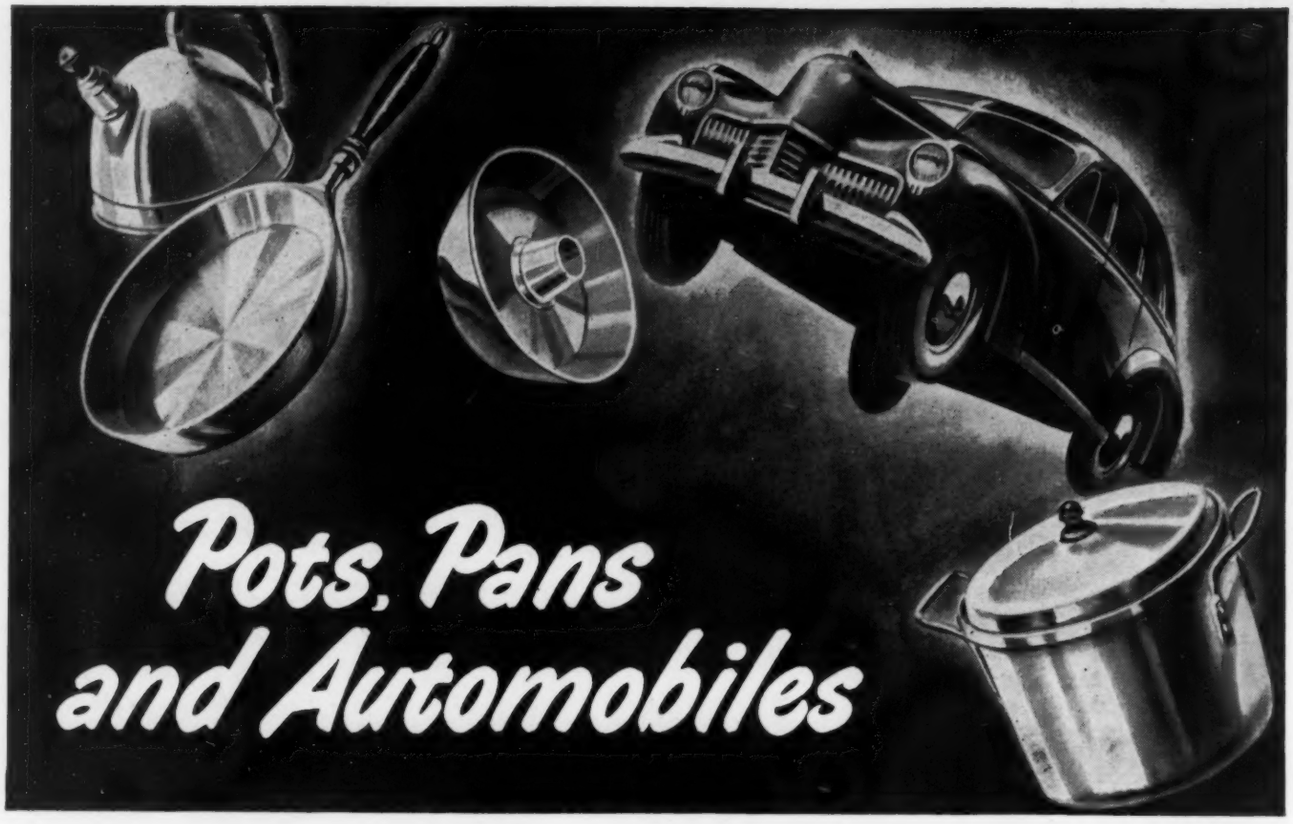
For almost half a century UNITED has been identified with the latest practice and highest standards in design and construction of Rolling Mills and related apparatus. Pioneers of many "firsts" in steel making, UNITED'S engineers are singularly fitted, by experience and training, to deal intelligently with problems of the rolling industry.

Six large plants provide unparalleled production facilities.

**United Engineering and Foundry Company · *Pittsburgh, Pa.***

**Plants at PITTSBURGH · VANDERGRIFT · NEW CASTLE · YOUNGSTOWN · CANTON**
**Subsidiary: Adamson United Company, Akron, Ohio**
**Affiliates: Davy and United Engineering Company, Ltd., Sheffield, England**
**Dominion Engineering Works, Ltd., Montreal, P. Q., Canada**

*★ The World's Largest Designers and Makers of Rolls and Rolling Mill Equipment*




# A-B-K Laminated Plastic Bearings

## Help supply the steel

With an unprecedented demand for civilian goods ahead, the nation's steel mills are called on for volume production. Checks made under peak production conditions prove A-B-K Laminated Plastic Bearings superior to other types of bearings.

★ More tons of steel are rolled per set of A-B-K roll neck bearings because rolls do not require adjustment so frequently. Sheets are rolled to closer tolerances and A-B-K bearings outlast metal bearings.

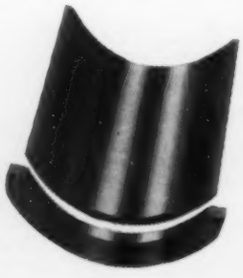
★ Costly delays and shut down periods for bearing replacement are avoided.

★ Power consumption is lowered.

★ Roll Neck lubrication costs are practically eliminated.

A-B-K Laminated Plastic Bearings were designed by American Brakeblok to do the hard jobs. Their record is a success story that speaks for itself.

The same engineering and research facilities which created these bearings are available to help with your steel mill bearing problems. Phone, wire or write, American Brakeblok Division, 4600 Merritt Avenue, Detroit 9, Michigan.



A-B-K Roll Neck Bearing with separate collar.

A-B-K Patented Reinforced Edge Slipper Bearing made to specified blue print sizes.

Phantom view of A-B-K Patented Reinforced Edge Slipper Bearing.

American Brakeblok

AMERICAN Brake Shoe COMPANY

AMERICAN BRAKEBLOK DIVISION
DETROIT 9, MICHIGAN

# A new challenge to *HEAT TREATING* costs

● The results obtained with the F.E.I. Direct Fired System in actual installations, some of considerable magnitude, presents a new challenge to present heat treating costs in many plants, especially where operations are on a large scale. It is not a question of minor differences in cost, establishing a small margin of advantages for F.E.I., but of really important reductions in unit cost, coupled with space saving, simple, trouble-free operation, better, more uniform quality. The facts are most convincing. Ask for service records and let F.E.I. engineers make recommendations for conversion of your present Cover Annealing Furnaces or installation of new units.

**Direct-Fired Cover Annealing Furnaces for coiled strip, tin plate, flat sheets, wire and rod.**

●

**Spheroidizing, normalizing and bright annealing furnaces.**

●

**Galvanizing, patenting, lead annealing and salt furnaces for the wire industry.**

●

**Galvanizing furnaces for pipe, sheets and the jobbing trade.**

## FURNACE ENGINEERS, *Inc.*

***Specializing in the design, manufacture and installation of furnaces for the metal working industries***

1551 WEST LIBERTY AVENUE ★ PITTSBURGH, PA.

Designed exclusively for table rollers, these sturdy, two-piece pillow blocks permit the *most* load carrying capacity in the *least* space. They're readily adaptable for use with a central lubricating system, they may be cast in iron or steel, and they're equipped with the exclusive SKF Triple Seal that keeps lubricant *in* . . . dust, scale and water *out*. Let our engineers show you how SKF Pillow Blocks can reduce operating costs by protecting the bearings on *your* table rollers.

5969

**SKF** INDUSTRIES, INC.
Front Street & Erie Ave., PHILA. 34, PA.

SKF
BALL AND ROLLER
BEARINGS

# HOW Alliance KEEPS CRANES FROM GETTING OLD

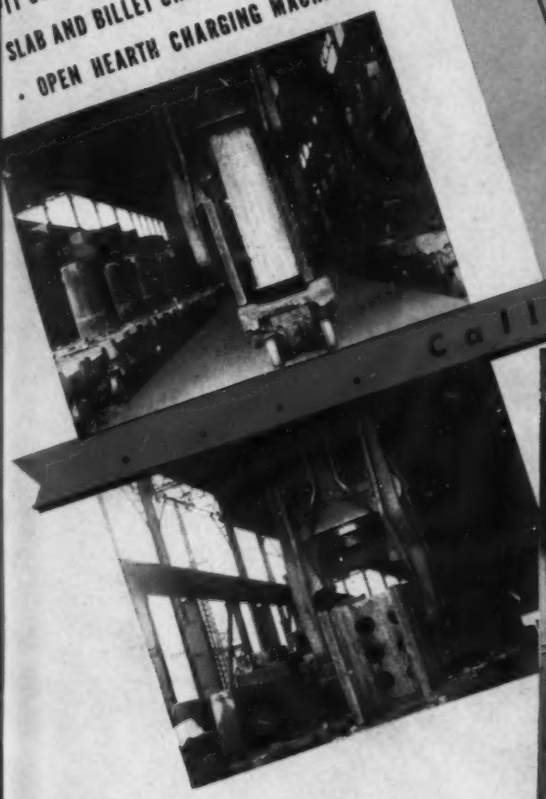
Operating and maintenance men judge crane performance by the number of years of trouble-free service. Alliance always has rated high for quality construction, as exemplified by these features:

1. To prevent entrance of dirt and leakage of lubricant, all bearings (brass and roller) are completely sealed.
2. To prevent bearings getting out of line and to avoid loosening of bolted connections, trolley frames are a one-piece steel casting or weldment.
3. To prevent cranes getting out of square and twisting of girders, end connections of girders are of ample section.
4. To make maintenance easy, all working parts are easily accessible.
5. To help prevent accidents, Alliance provides full vision cabs and convenient location of controls.

*Alliance, world's largest builder of the world's largest cranes, builds many types of load handling equipment for mills.*

LE CRANES • GANTRY CRANES •
RGING MANIPULATORS • SOAKING
IT CRANES • STRIPPER CRANES •
SLAB AND BILLET CHARGING MACHINES
• OPEN HEARTH CHARGING MACHINES

Call ALLIANCE FOR CRANES



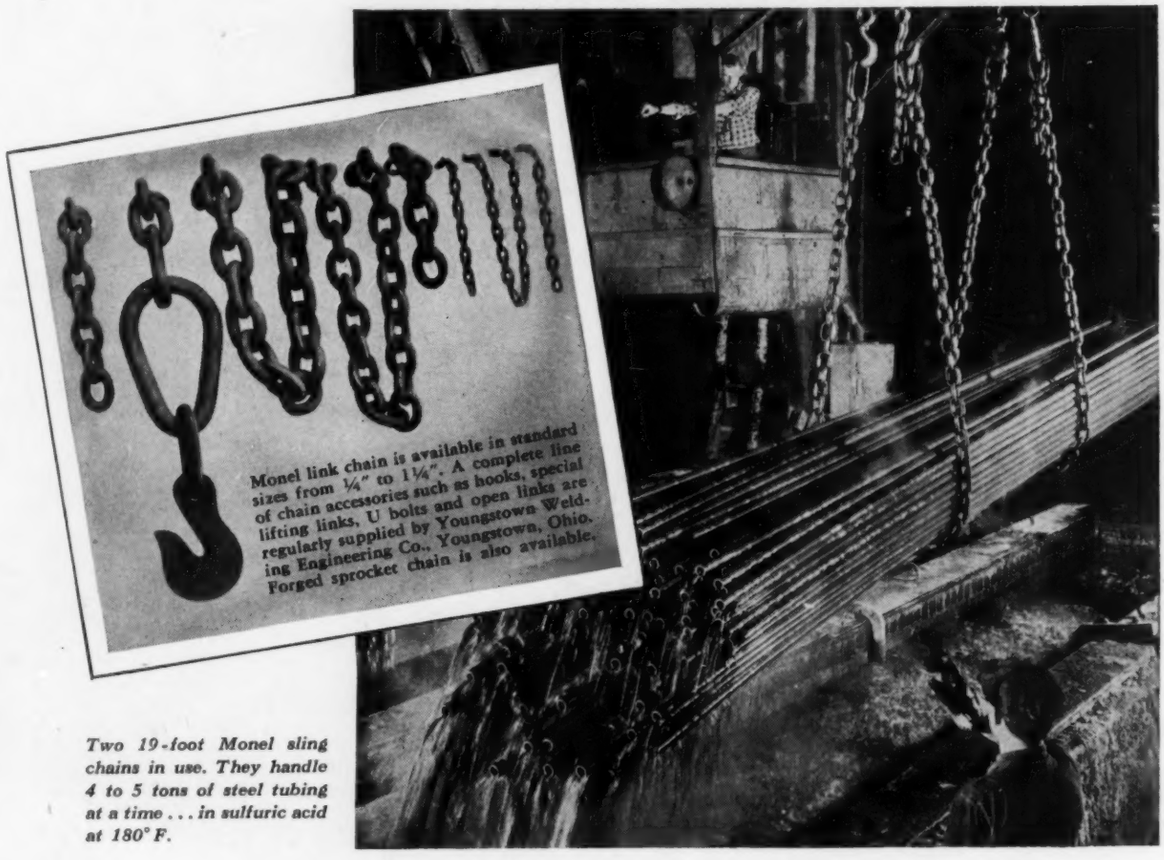
THE ALLIANCE MACHINE COMPANY • ALLIANCE, OHIO

ARMY E NAVY

PITTSBURGH, PA., OFFICE — 1622 OLIVER BLDG.

# "For our **HEAVIEST** loads we use LIGHTWEIGHT chain!"

***...says steel mill pickling superintendent***


Monel link chain is available in standard sizes from ¼" to 1¼". A complete line of chain accessories such as hooks, special lifting links, U bolts and open links are regularly supplied by Youngstown Welding Engineering Co., Youngstown, Ohio. Forged sprocket chain is also available.

*Two 19-foot Monel sling chains in use. They handle 4 to 5 tons of steel tubing at a time ... in sulfuric acid at 180° F.*

Which would you consider safer ... ¾" chain that had already seen 6 years' service ... or 1¼" chain only 9 months old?

The newer, heavier chain, you say? Read what this user reports:

> *"... the 1¼" cast acid-resisting chain began to need repairs after nine months of service. So—in spite of the great difference in size—whenever we have particularly severe loads, we use the ¾" Monel chain. Although it is over six years old, we find it reliable and not subject to sudden breaks, as is the case with the cast acid-resisting chain."*

Monel* pickling chain is made from hot-rolled Monel rod, formed in specially designed dies. The links are welded. Made in this way it is much stronger and tougher than the cast acid-resisting type.

Even *more* important, Monel chain resists corrosion by pickling acids ... it *retains* its strength and thus provides years of trouble-free, economical service. The same is true of crates, baskets, tie-rods and other Monel pickling equipment.

Practical, usable information which can help you increase pickling room efficiency is contained in the booklet, "Safety and Service with Monel Chain." Write for *your* copy *now* ... before it slips your mind.

The International Nickel Company, Inc., 67 Wall Street, New York 5, N. Y.

*Reg. U.S. Pat. Off.

**Monel**

# Unique Plate-Type HEAT EXCHANGER

## FOR PICKLING, ETCHING, PLATING, CLEANING

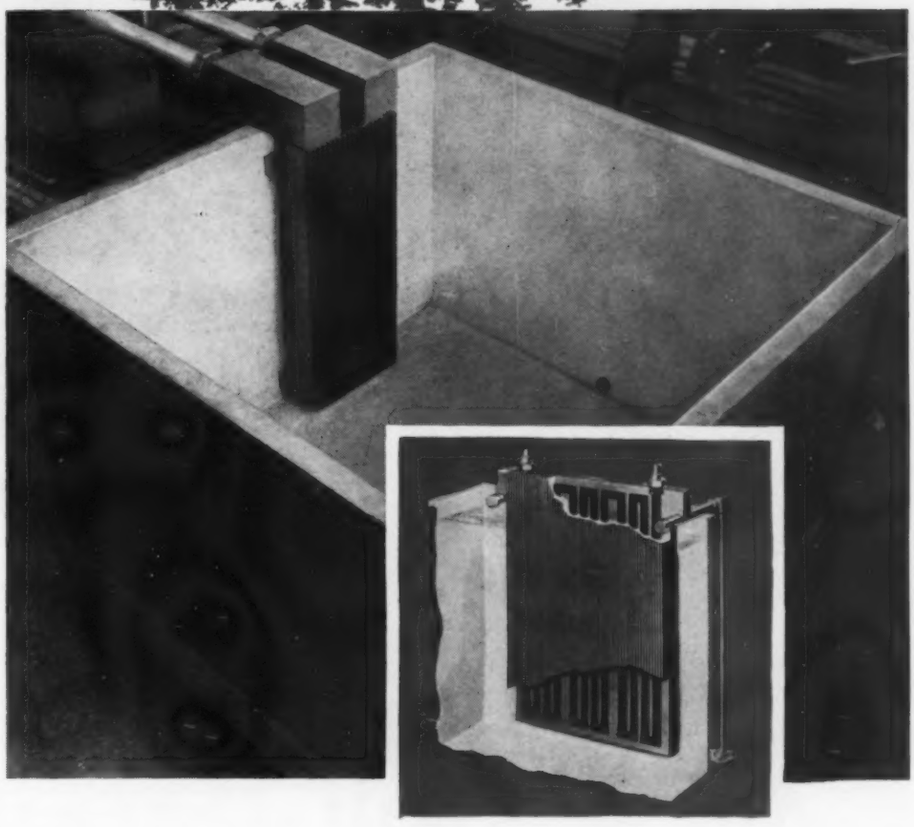
**MADE OF**

## "KARBATE"

**BRAND**

IMPERVIOUS GRAPHITE

IT IS CORROSION-RESISTANT AND PROVIDES HIGH HEAT TRANSFER



*The "Karbate" Plate-Type Heater installed in a pickling tank, and a cut-away drawing of its construction.*

DEVELOPED by National Carbon Company, Inc., and thoroughly proved in the field, the "Karbate" Plate-Type Heat Exchanger combines chemical inertness with high heat transfer and resistance to thermal and mechanical shock.

Thus, this unique heat exchanger is not affected by hydrochloric, dilute sulphuric, mixtures of nitric and hydrofluoric acids, or by chlorinated organic compounds. This... plus its unusual strength and sturdiness... makes the "Karbate" Heat Exchanger ideal for almost all heating and cooling operations.

This heater is especially valuable in pickling, etching, plating, or cleaning—where a heat exchanger must often take rough treatment. Still another advantage in plating and pickling is that it prevents dilution of the solution.

Simple in design and construction, the plates, or blocks, have tubular channels for flow of heating or cooling liquid. The outer surface is corrugated for utmost heat transfer. The units are light in weight, compact, easily installed, and available in various sizes. They may also be used in multiple, providing the desired capacity.

• • •

For more details, write for Catalog Section M-8804.

**NATIONAL CARBON COMPANY, INC.**

*Unit of Union Carbide and Carbon Corporation*
The words "National" and "Karbate" are registered trade-marks of National Carbon Company, Inc.

UCC

*General Offices:* 30 E. 42nd St., New York 17, N. Y.
*Division Sales Offices:* Atlanta, Chicago, Dallas, Kansas City, New York, Pittsburgh, San Francisco

# "I FOUND a way to save $24,480.00 in my Wastebasket"

"Something caught my eye in the wastebasket . . . a trade journal I had flipped through and discarded. It was turned up to an ad which promised a 46% saving in material handling costs. When they talked about cutting my handling costs that much, well, I wanted to be shown.

"Literature told how this saving could be accomplished simply through the use of a bright, shiny orange and black electric truck called 'Transporter' . . . the miracle truck that lightens life's loads. It was an impressive story. As a result I ordered one, and an A.T.C. Specialist showed up with it to demonstrate what they claimed.

"He piled 6000 pounds of our most unwieldy product on it. Then asked for one of our stenographers . . . and she promptly walked off with the load as easy as she'd powder her nose. Her thumb pressed a button, her hand gently guided it. That's all there was to it. Husky truckers accustomed to a three-man operation moving similar loads were amazed . . . couldn't wait to try this wonder truck that meant for them an end to back-breaking, gruelling toil.

"I was more than sold on Automatic Transporters. They have cut our material handling costs 46% . . . a solid $24,480.00 saved*—the equivalent of $244,800.00 worth of increased volume on a 10% profit basis. That's the money-saving, profit-making opportunity I found in my wastebasket."

Such savings may be duplicated many times over during the life of Transporters . . . may be multiplied many times depending on the size of your material handling operation. Mail the coupon for complete facts.

***Remember: Only AUTOMATIC Makes the TRANSPORTER***

**Transporter**
A PRODUCT OF AUTOMATIC
*Lightens* LIFE'S LOADS

**Case 10 in "Automatic Savings Parade"*

AUTOMATIC TRANSPORTATION COMPANY
Div. of The Yale & Towne Mfg. Co.
47 West 87th Street, Dept. B, Chicago 20, Ill.

Please mail me, without cost or obligation, complete facts about AUTOMATIC TRANSPORTER, the miracle electric truck . . . plus *proof* that it has cut handling costs in half.

☐ Have an A.T.C. Material Handling Specialist call.

Company Name.....

*By*.....*Position*.....

*Street Address*.....

*City*.....*State*.....

*Announcing*

THE TORRINGTON SELF-ALIGNING

# SPHERICAL ROLLER BEARING

In addition to the many advantages provided by Torrington's proficient engineering and precision manufacturing, the new Torrington Spherical Roller Bearing offers these features:

- Self-Alignment
- Two-Directional Thrust
- High Radial Capacity
- High Thrust Capacity
- Unit Construction for Easy Installation

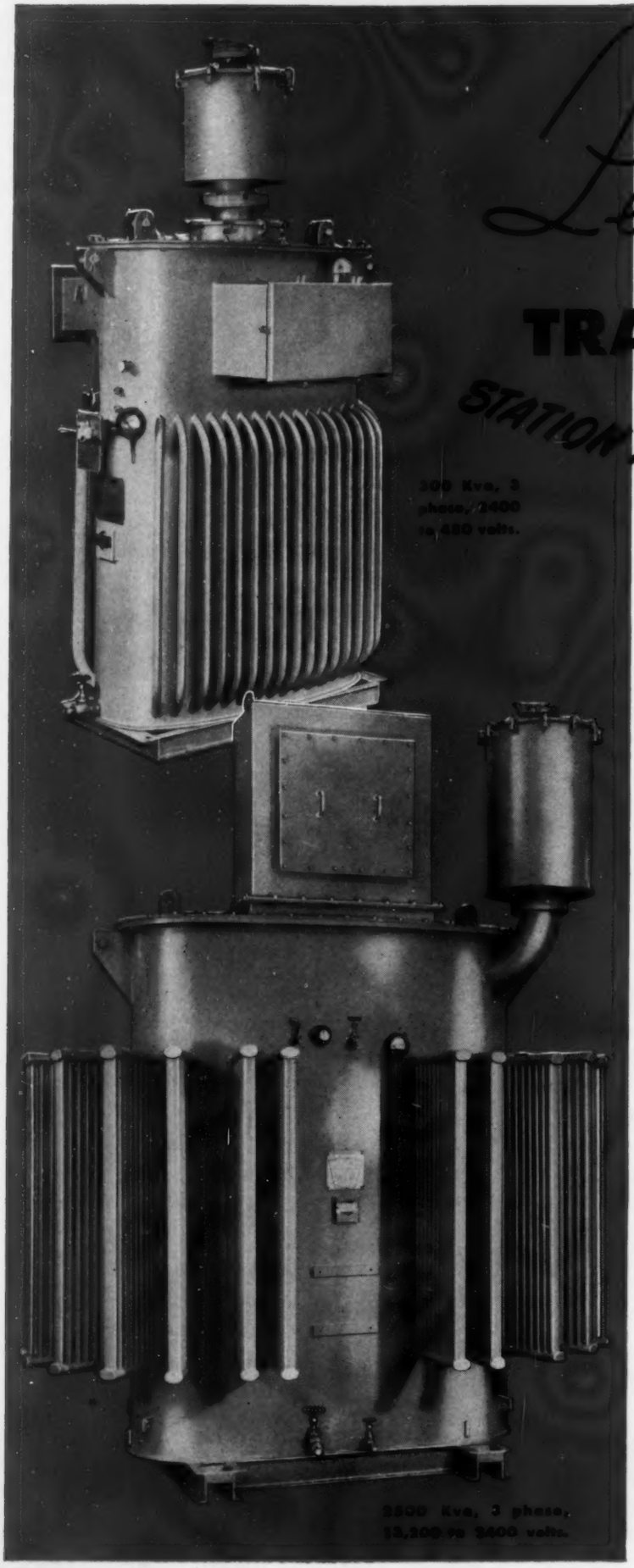
To meet the increasingly exacting demands of industry, Torrington has added to its regular line a bearing specifically adaptable to heavy-duty performance... the Self-Aligning Spherical Roller Bearing.

This new bearing will be available in a full range of sizes from 1.5748" bore and up. It is backed up by the same specialized engineering knowledge which for years has made Torrington's Bantam Bearings Division a leader in the design and construction of custom-built bearings. For further information write for our Bulletin No. 100A.

THE TORRINGTON COMPANY • BANTAM BEARINGS DIVISION
SOUTH BEND 21, INDIANA

# TORRINGTON BEARINGS

SPHERICAL ROLLER • STRAIGHT ROLLER • TAPERED ROLLER • NEEDLE • BALL




# Pennsylvania TRANSFORMERS FOR STATION AUXILIARY SERVICE

Shown are two of an installation of four Askarel filled, self cooled Pennsylvania Transformers designed to supply power for 2400 volt and 480 volt motors driving the station auxiliary pumps, fans, pulverizers, etc., for a new turbo-generator in the plant of an Atlantic Coast utility. One of the essential requirements of such transformers is reliability.

The installation consists of two 2500 Kva, 3 phase, 13,200 to 2400 V units, and two 300 Kva, 3 phase, 2400 to 480 V units, equipped with gas absorbers and arranged for bus connections to metal enclosed switch-gear.

These transformers were built to rigid specifications and embody the best in standard practice plus these Pennsylvania features: (1) Layer type winding resulting in high mechanical strength; (2) Tubes and radiators fabricated from No. 13 gauge steel tubes, the wall thickness of which permits making of strong welds.

For complete details on these and other Pennsylvania Power or Distribution Transformers, consult your nearest Pennsylvania Representative, or write direct to Pennsylvania Transformer Company.

Pennsylvania
TRANSFORMER COMPANY
808 Ridge Avenue, N. S.,
Pittsburgh 12, Pa.

Pennsylvania TRANSFORMERS

## Smooth, accurate regulation over the entire range of operation with the HAGAN V-Port Butterfly Valve

Accurate proportioning of fuel and air is essential in the modern furnace, where heat input may vary over a turndown range of 10 to 1. The need is particularly great at the low rates because at this time steel is up to temperature and most sensitive to furnace atmosphere.

At a minimum flow, the differential across regulating valves is usually the greatest. Losses across the measuring orifice, duct work and burner decrease, so that loss across the regulating butterfly must increase by a corresponding amount.

In the Hagan V-Port Butterfly Valve all of these factors are taken into account in port design, and smooth, accurate regulation is secured over the entire range of operation. The shape of the ports can be made to suit any given set of conditions, so that full advantage is taken of the inherent sensitivity and accuracy of regulating equipment.

Hagan V-Port Butterfly Valves are made in standard pipe sizes. They are ruggedly built and accurately machined. Our engineers will be glad to give you full information.

HAGAN HALL BUROMIN CALGON

HAGAN CORPORATION, HAGAN BUILDING · PITTSBURGH 30, PA.

HAGAN *Automatic* COMBUSTION CONTROL

*The pioneer . . . and still the leader*

# JUST SAY CRANE . . .

## For Everything In Piping Materials

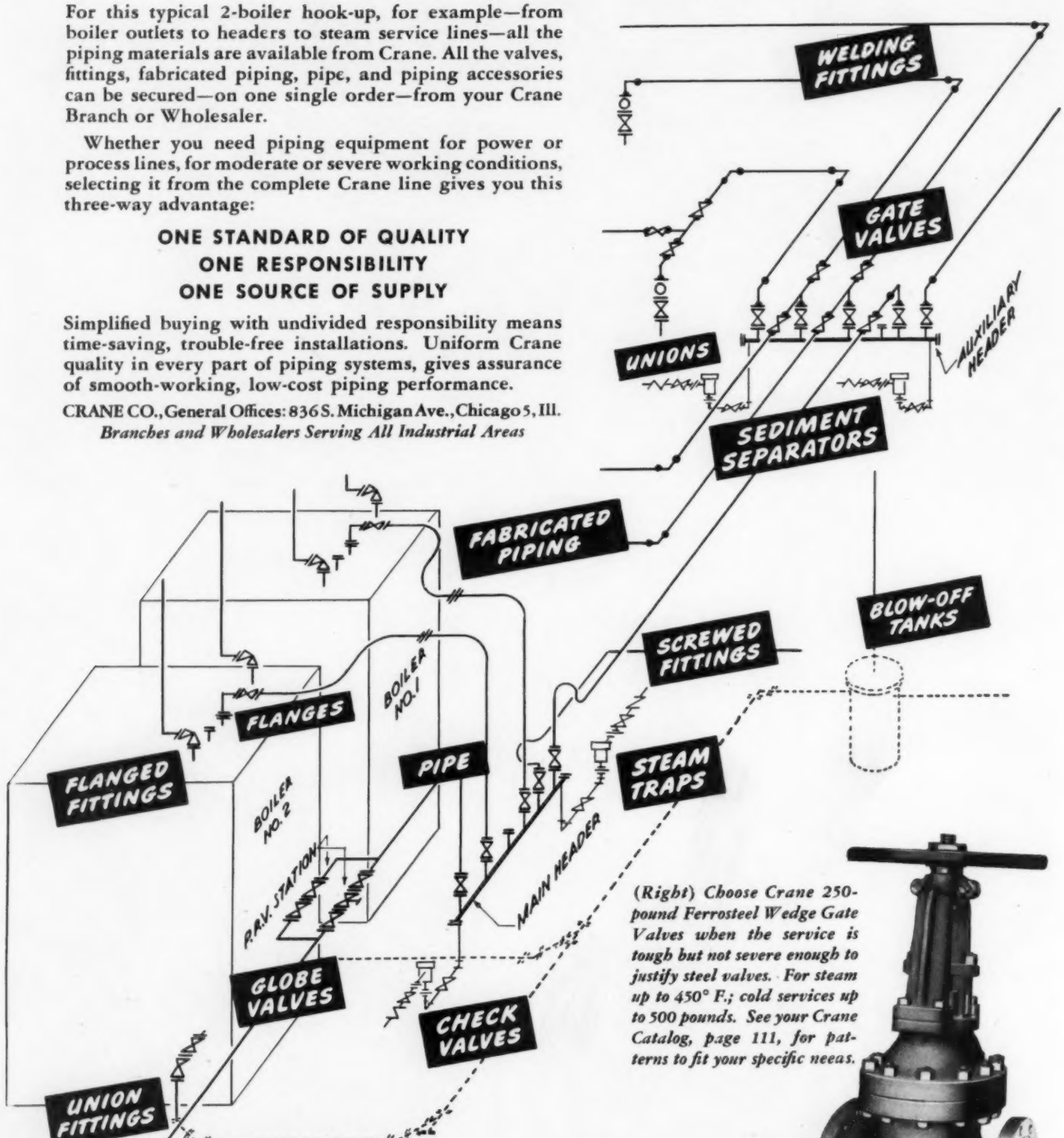
For this typical 2-boiler hook-up, for example—from boiler outlets to headers to steam service lines—all the piping materials are available from Crane. All the valves, fittings, fabricated piping, pipe, and piping accessories can be secured—on one single order—from your Crane Branch or Wholesaler.

Whether you need piping equipment for power or process lines, for moderate or severe working conditions, selecting it from the complete Crane line gives you this three-way advantage:

**ONE STANDARD OF QUALITY**
**ONE RESPONSIBILITY**
**ONE SOURCE OF SUPPLY**

Simplified buying with undivided responsibility means time-saving, trouble-free installations. Uniform Crane quality in every part of piping systems, gives assurance of smooth-working, low-cost piping performance.

CRANE CO., General Offices: 836 S. Michigan Ave., Chicago 5, Ill.
*Branches and Wholesalers Serving All Industrial Areas*




*(Right) Choose Crane 250-pound Ferrosteel Wedge Gate Valves when the service is tough but not severe enough to justify steel valves. For steam up to 450° F.; cold services up to 500 pounds. See your Crane Catalog, page 111, for patterns to fit your specific neeas.*

. . . EVERYTHING FROM

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VALVES • FITTINGS
PIPE • PLUMBING
HEATING • PUMPS

FOR EVERY PIPING SYSTEM

Central control station for two-zone heat-treating furnaces at Spicer Manufacturing Co., Detroit . . . makers of Universal Joints, Clutches, Gears, etc.

# FOR SMOOTH CENTRALIZED CONTROL

## MICROMAX Instruments Give Top Efficiency

When Spicer Mfg. Co., during expansion of its Detroit operations, centralized control of its large carburizing, tempering, hardening and annealing furnaces, careful consideration of instruments ended in the selection of Micromax Controllers for the job, because of their dependability and convenience.

In large-scale instrumentation such as Spicer's, Micromax's always helpful self-standardizing feature is a particular asset, saving in this case about one man-hour per day. This is in addition to its fundamental advantage of maintaining the full accuracy of the potentiometer's recording and control circuits.

Among the convenience features are the cell-condition indicator and a "tell-tale" which shows whether the instrument is in service. Ink and recorder chart warn well in advance when refills are needed. To communicate other information, "bull's-eye" or other signals can be automatically operated.

In addition to the two-position motorized control which Spicer uses, Micromax instruments can give control of proportioning or program types. The roomy Micromax case allows for extra equipment required for a complex control problem. And there's a model and range of instrument to match the need in any given application.

These catalogs are sent on request or, if you prefer, an L&N engineer will gladly call.

LEEDS & NORTHRUP COMPANY, 4942 STENTON AVE., PHILA., PA.

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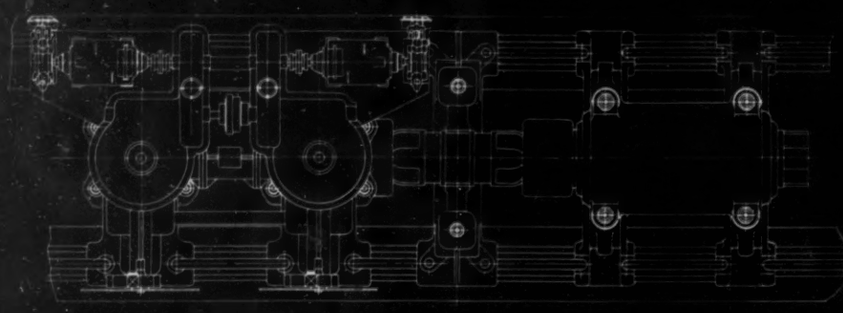
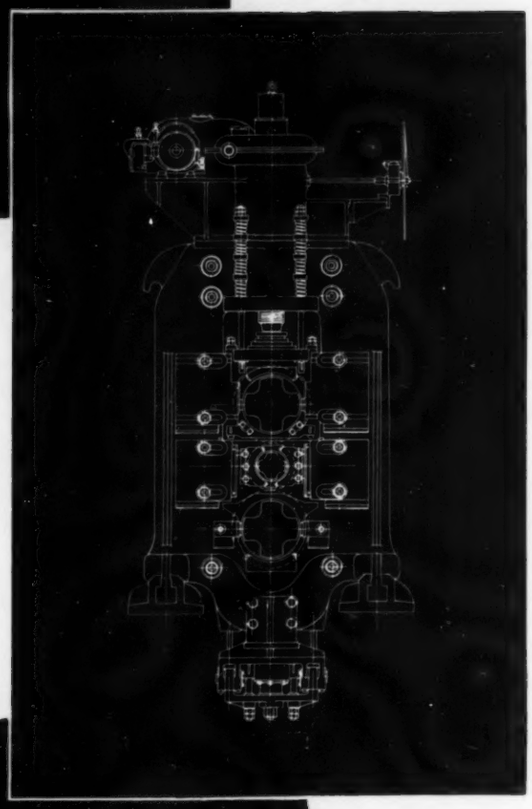
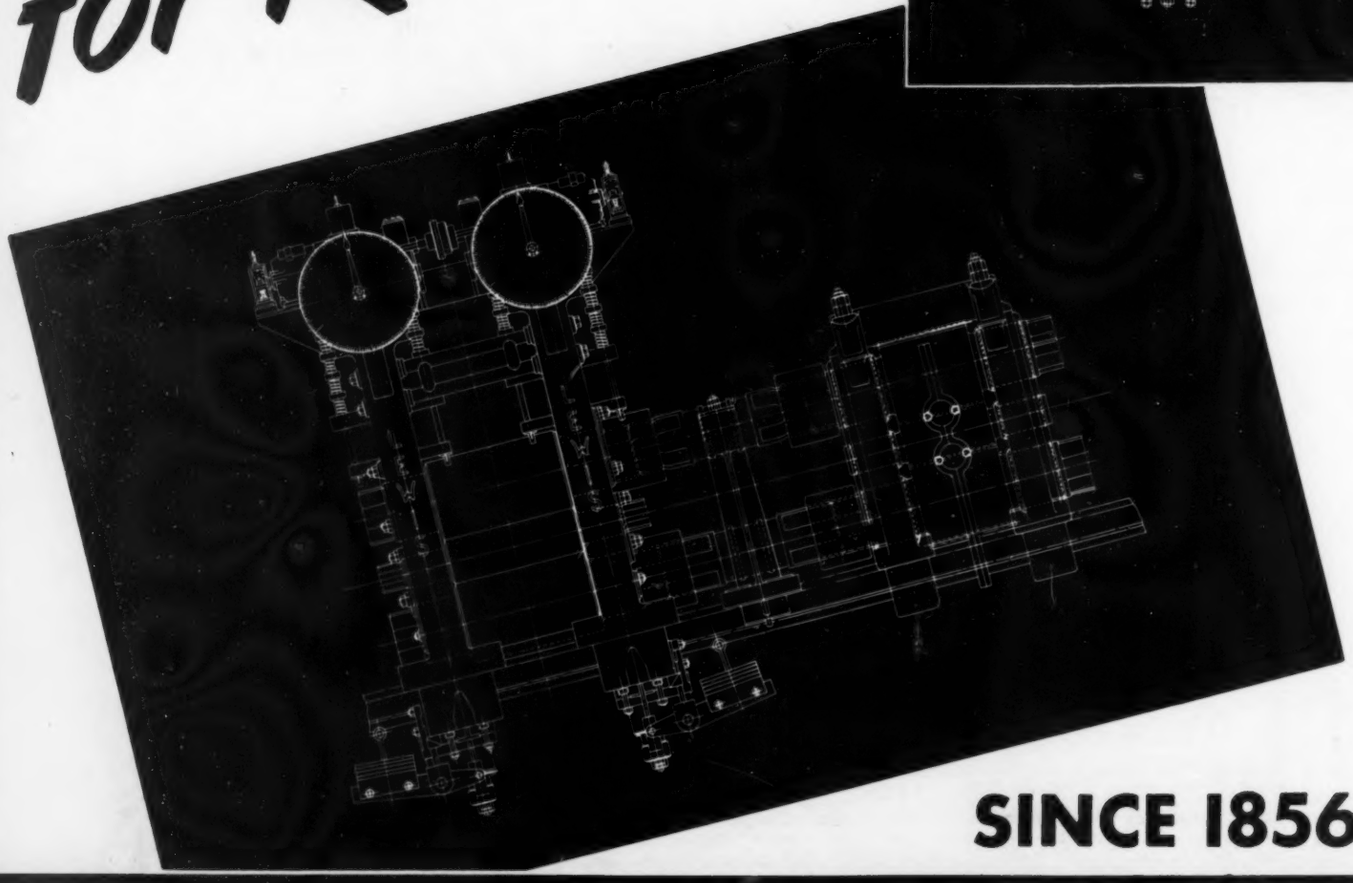




# Design for Rolling



SINCE 1856

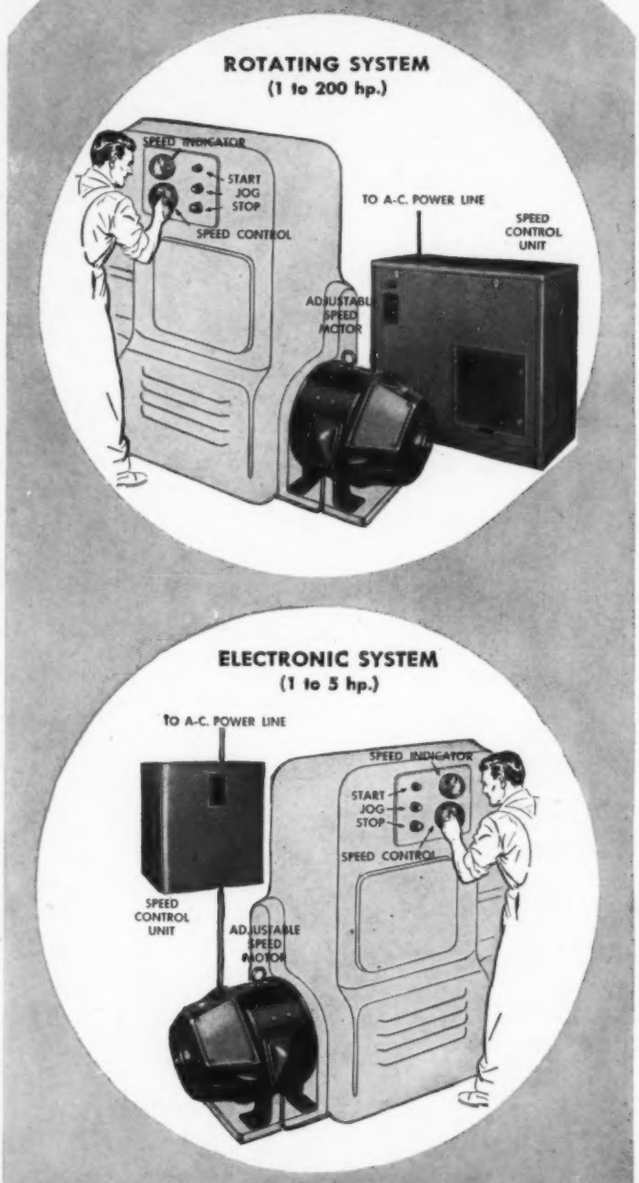
## LEWIS FOUNDRY & MACHINE

DIVISION OF BLAW-KNOX COMPANY, PITTSBURGH, PA.

# Why pay more than you need

RELIANCE V★S DRIVE

## to get D-c. Power where you want it?




## *Save* $25 to $60 per Kilowatt of installed D-c. capacity with RELIANCE V★S DRIVE

If in your plant—as in so many others—there is a need for supplying D-c. power for adjustable-speed operations, you are likely to find that *spot conversion of A-c. power* with the Reliance V★S Drive is the perfect answer. This is true for two reasons.

**FIRST—V★S DRIVE** saves you from $25 to $60 per kilowatt as compared to the cost of bringing in and applying D-c. power from some central source. These figures are based on a wide variety of applications.

**SECOND—V★S DRIVE** gives you unlimited flexibility of machine operation and application. This includes both automatic and manual control with smooth starting, stopping and reversing. Also, an infinite range of stepless speed changes, automatically maintained tension and many other specialized advantages.

Before installing D-c. power lines, learn what you can save with Reliance V★S Drive, which operates from your regular A-c. circuits. And see what V★S, with all-electric control, can do in improving quality and quantity of output, while reducing installation, operating and maintenance costs. Write today for the up-to-date story on spot conversion of A-c to D-c power.

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**RELIANCE A-C D-C MOTORS**

*"Motor-Drive is More Than Power"*

Length 32 in.
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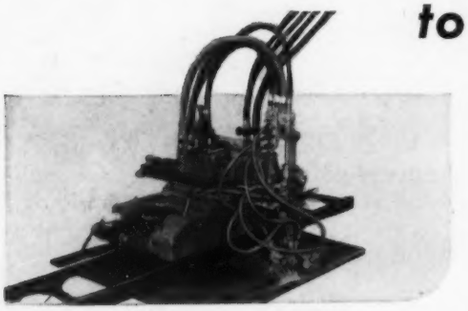
Speed – standard machine 2 to 50 inches per minute... high speed machine 7 to 210 inches per minute. Equipped with direct, continuous reading speedometer... inherently accurate.

Heavy Load Capacity – 500 lb.

Adaptability – Runs on special track, I-beams, or any flat surface.

# An Electric "PACK MULE"

## *to mechanize these processes*



**CUTTING**

Straight Line Cutting
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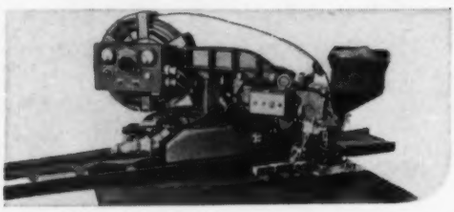

**WELDING**

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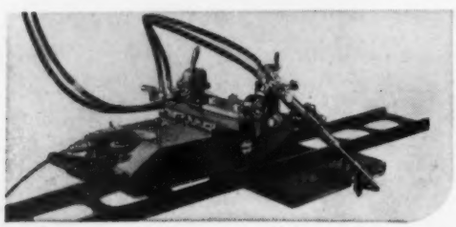
Mechanized Oxy-Acetylene Welding



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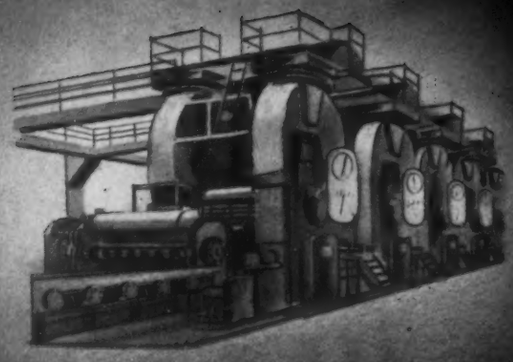

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Headquarters for the latest engineering developments in blooming, slab, plate, structural, merchant, bar, tube and sheet mills, manipulators, tables, pinion stands, shears, roll lathes, furnace pushers for slabs and billets and other special equipment used in steel and non-ferrous rolling mills.

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Continental Iron Rolls are produced from Chilled Iron, Molybdenum Chilled Iron, Grain Iron, Sand Iron, Continental "CA" and "GI," Cromonite and Crasfloy to fit your design and product requirements.

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Carbon Steels to desired carbon analyses, Heat Treated Alloys, Chrome Molybdenum Steels. Continental Rolls are built to meet the most difficult heat, strength and wear resistance needs.

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- Continuous Tube Mills
- Piercing Mills
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- Mill Tables
- Conveyors
- Rod Reels
- Hot Strip Coilers
- Cold Strip Coilers
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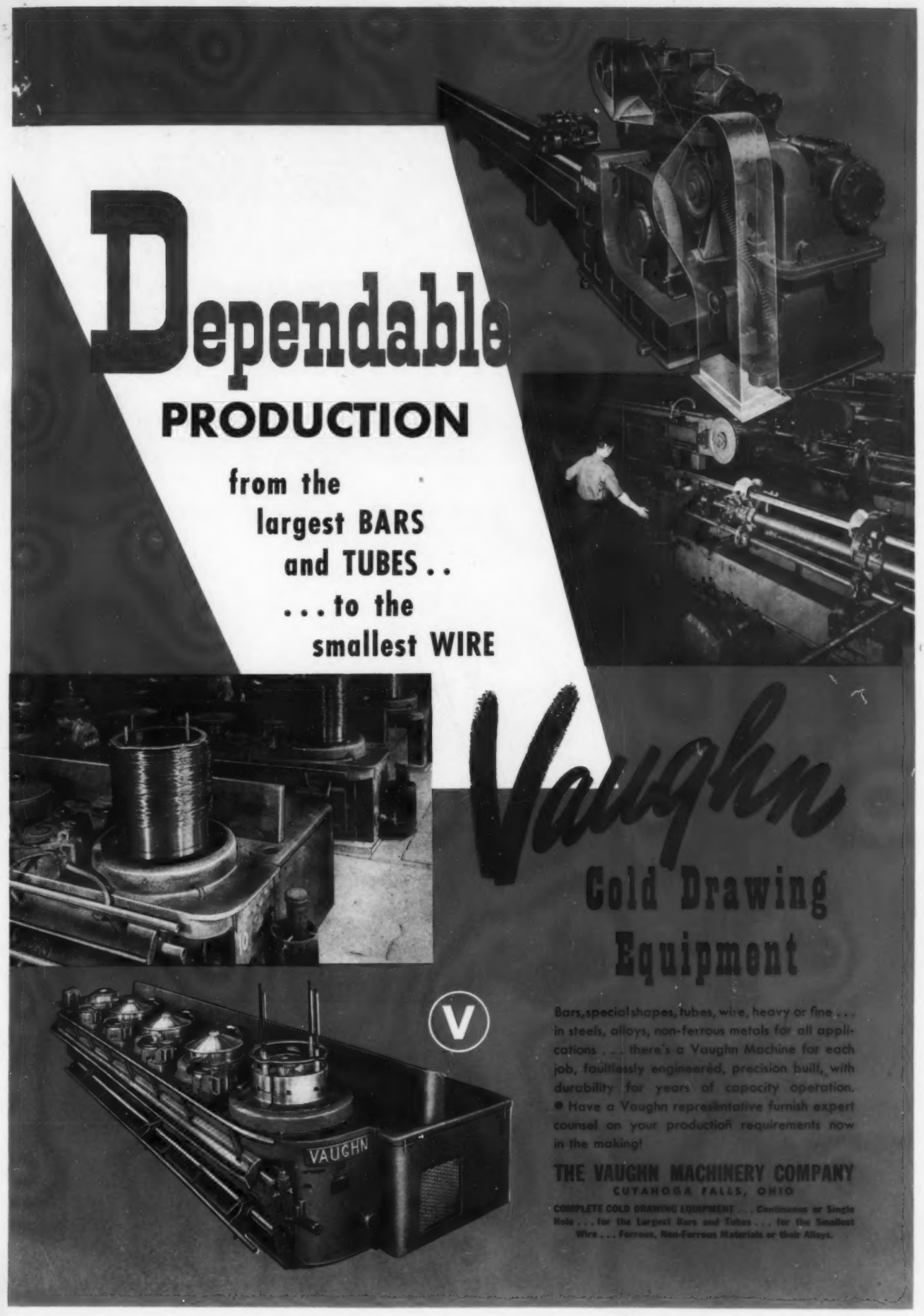
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COMPLETE COLD DRAWING EQUIPMENT... Continuous or Single Hole... for the Largest Bars and Tubes... for the Smallest Wire... Ferrous, Non-Ferrous Materials or their Alloys.

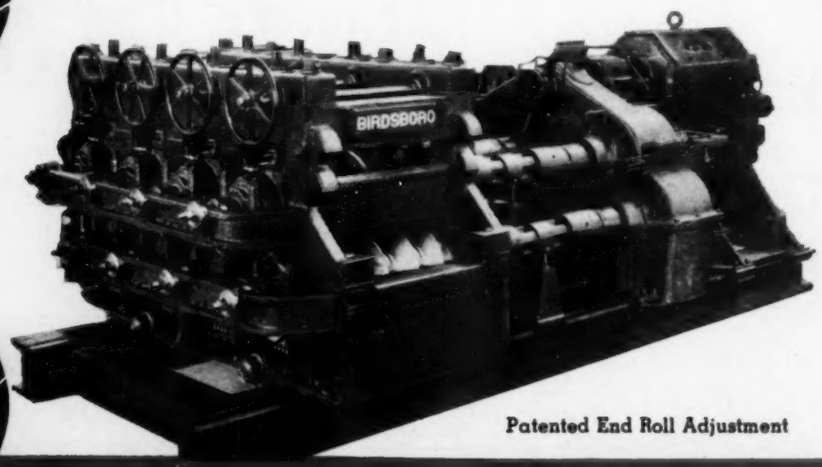
# FASTER, MORE ACCURATE Straightening

ON ANY OF THESE

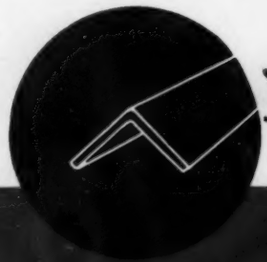
**BIRDSBORO**

STRAIGHTENING MACHINES

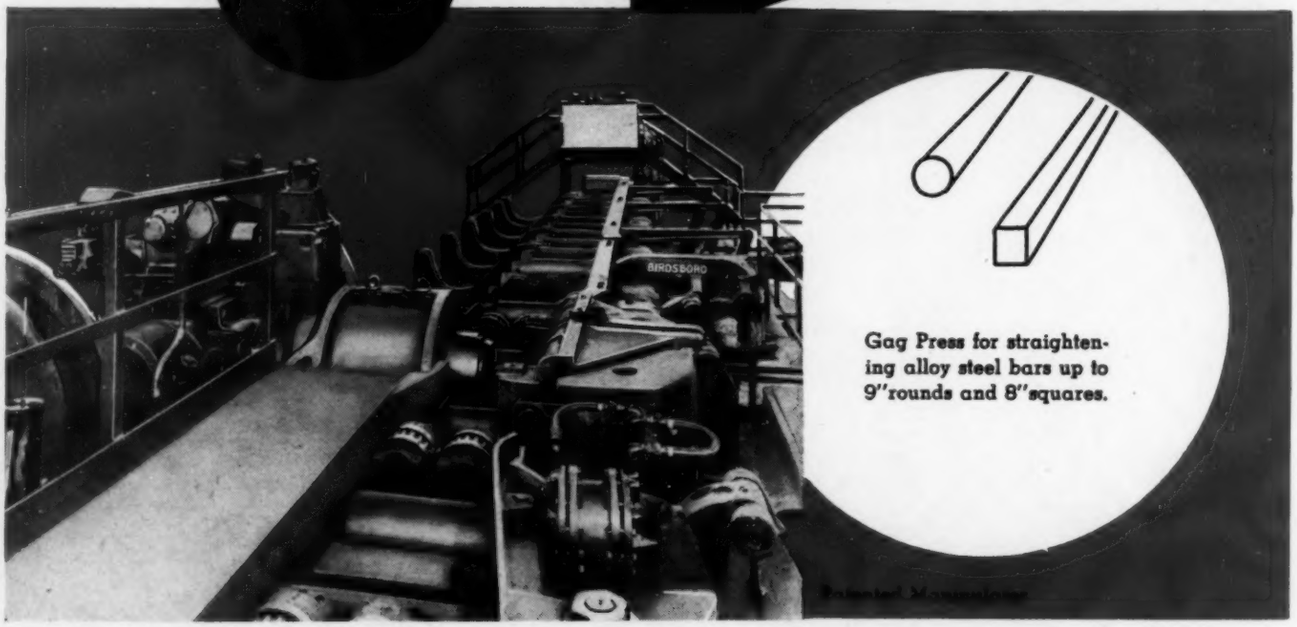
Rail Straightening Press having capacity for straightening 150 lb. rails.



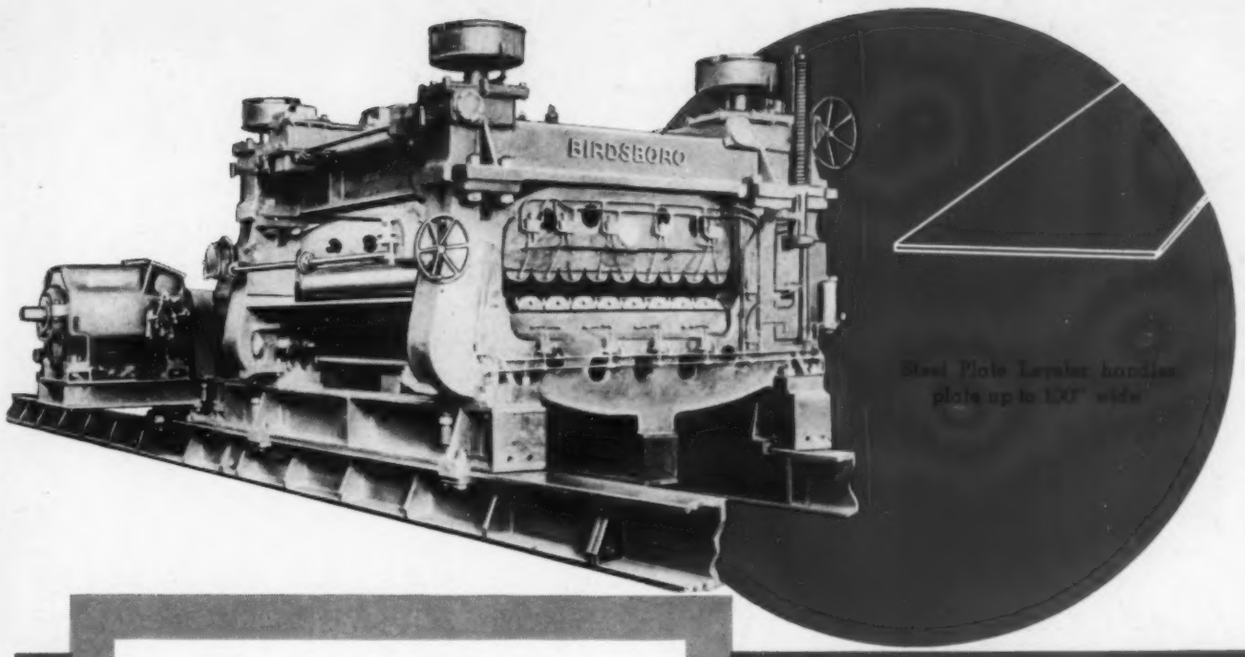

Structural Shape Straightening Machine with capacity up to 6" x 6" angles.

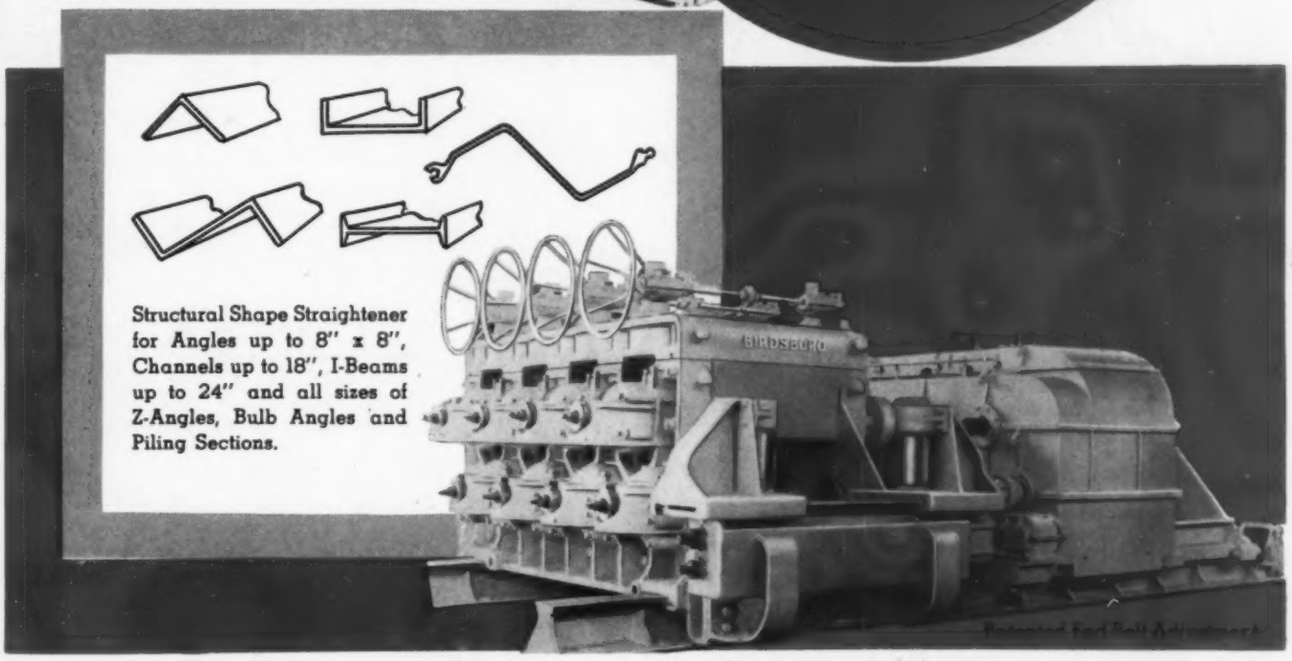


Patented End Roll Adjustment




Gag Press for straightening alloy steel bars up to 9"rounds and 8"squares.





Structural Shape Straightener for Angles up to 8" x 8", Channels up to 18", I-Beams up to 24" and all sizes of Z-Angles, Bulb Angles and Piling Sections.
BIRDSBORO

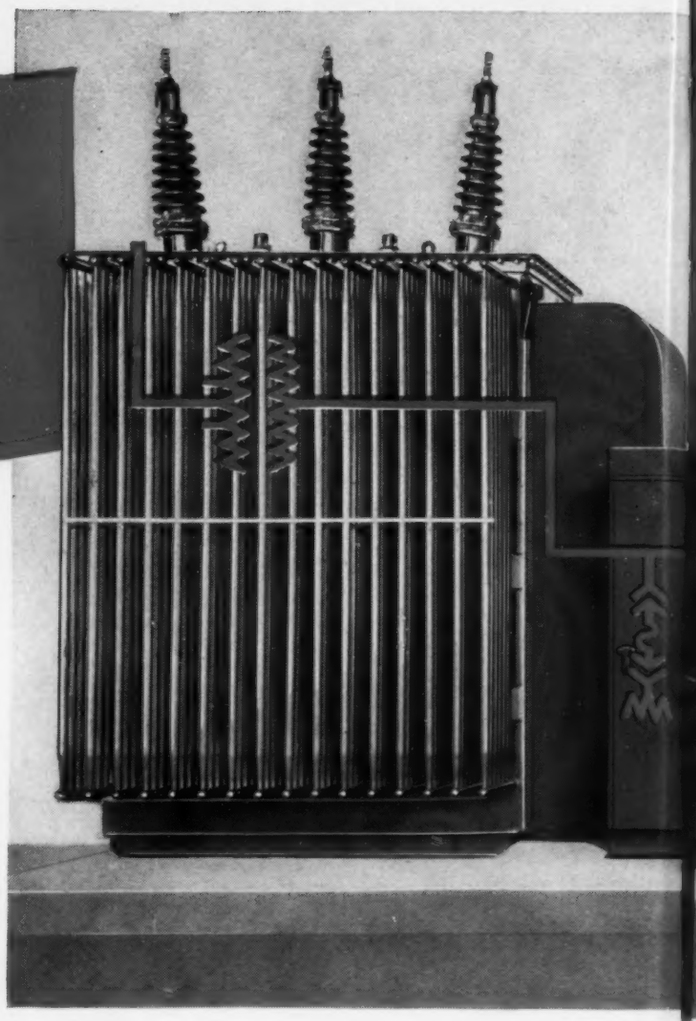
**These five versatile Birdsboro Machines meet the major straightening needs of heavy industry. They have been designed for easy, trouble-free operation and built for rugged service . . . with recently developed features that reduce production costs.**

**When your problem involves the straightening of any metal shapes in large or small sizes, investigate Birdsboro's facilities for producing machinery to meet your specific requirements. Our designers and engineers will welcome the opportunity to work with you to arrive at a practical solution to your problem. Get in touch with us today.**

**BIRDSBORO STEEL FOUNDRY & MACHINE COMPANY • BIRDSBORO, PENNSYLVANIA**
Manufacturers of Steel Mill Equipment, Iron and Steel Rolls, Hydraulic Presses, Crushing Machinery, and Special Machinery

# BIRDSBORO
## STEEL MILL EQUIPMENT

# NOW 3 more BUILT-IN FUNCTIONS



1. **Individual feeder regulation**
2. **By-pass facilities for the feeder breakers, the current transformers, the regulating equipment, and the power transformers**
3. **Two complete power-supply paths to each of the outgoing feeders**

**This new master DUPLEX unit substation affords increased flexibility as to both substation design and function, together with a high degree of continuity of service. Where individual feeder regulation and by-pass facilities are required, the DUPLEX provides the way to do the job at remarkably low cost.**

The DUPLEX unit is especially well suited to locations where continuity of service is of prime importance, because:

- **It is completely automatic in operation**
- **Its operation is not dependent upon the correct operation of other units**
- **It is capable of maintaining, through either transformer, the total load normally carried by both**

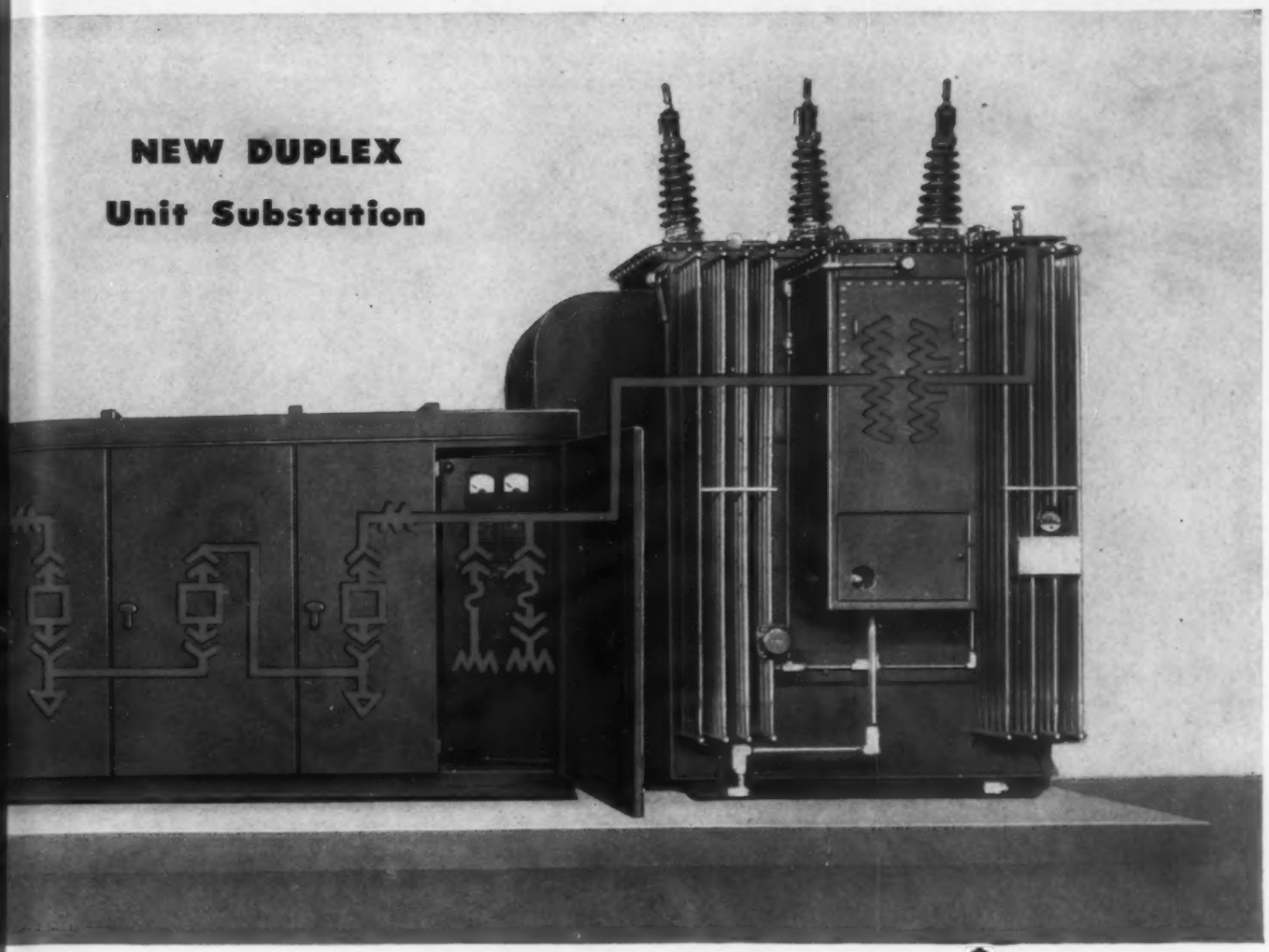
Don't overlook the fact that the DUPLEX is a standard G-E unit substation. Your over-all installed cost is low, and it is definitely predictable, because:

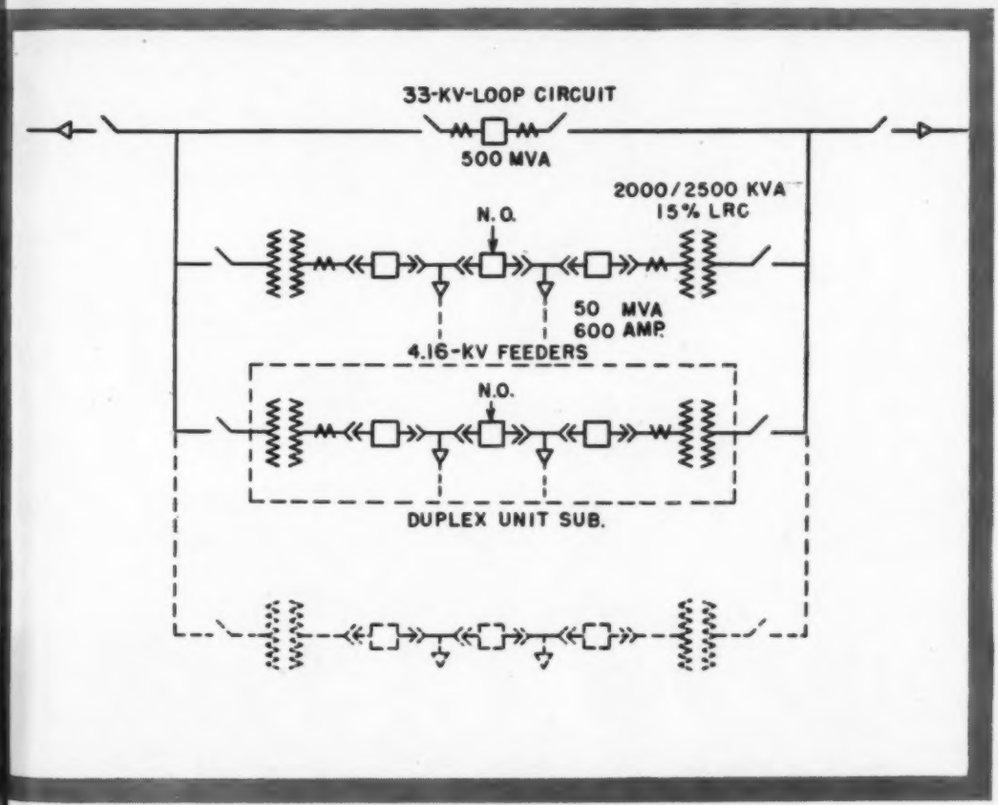
- **The DUPLEX is standard equipment**
- **It is repetitively manufactured**
- **It is completely assembled for you at the factory**

The DUPLEX unit substation can be used separately or in conjunction with identical units to make a substation with a total capacity as large as 20,000 kva. It is compact, easy to install, and easy to move.

Your local G-E sales engineer will be glad to give you further information. Ask him for a copy of Bulletin GEA-4478. *Apparatus Dept., General Electric Company, Schenectady 5, N. Y.*

**GENERAL ELECTRIC**




Relaying is so arranged that, if voltage disappears at the secondary of one transformer, the breaker on that side immediately opens and the tie breaker automatically closes, restoring service in approximately 105 cycles.

The DUPLEX provides a "building block" approach to the construction of standard substations which have a degree of operating flexibility heretofore obtained only by special engineering and construction. Small or large substations can be economically made up of the same basic unit. A single DUPLEX unit can be installed at first, and as the load grows, additional units can be added when they are needed.

GE

# UNIT SUBSTATIONS

# give your BILLETEER a new lease on life

During the past four years steel plants have slammed through tonnage equal to ten normal years' production. All your equipment has taken gruelling punishment. Even such a rugged machine as the Bonnot Billeteer never anticipated such unrelenting schedules.

But many more Billeteer production years lie ahead for manufacturers who let Bonnot rebuild — and improve — tired-out Billeteers . . . NOW while there is time.

Bonnot offers below three services which Billeteer owners find highly profitable.

## 1. reconditioning program

Replace all worn gears • renew base wearing plates • install new carriage shoes • repack air cylinders • replace or repair all other damaged or worn parts.

## 2. betterment program

*(includes program 1)*

Install *replaceable* base wearing plates and carriage shoes • add shock absorbing air cushions for billet turning • renew rolls and roll mountings on roll table.

*FEATURE: This betterment program eliminates necessity for sending Billeteer to Bonnot for future overhauls when plant maintenance departments are equipped to install replaceable parts.*

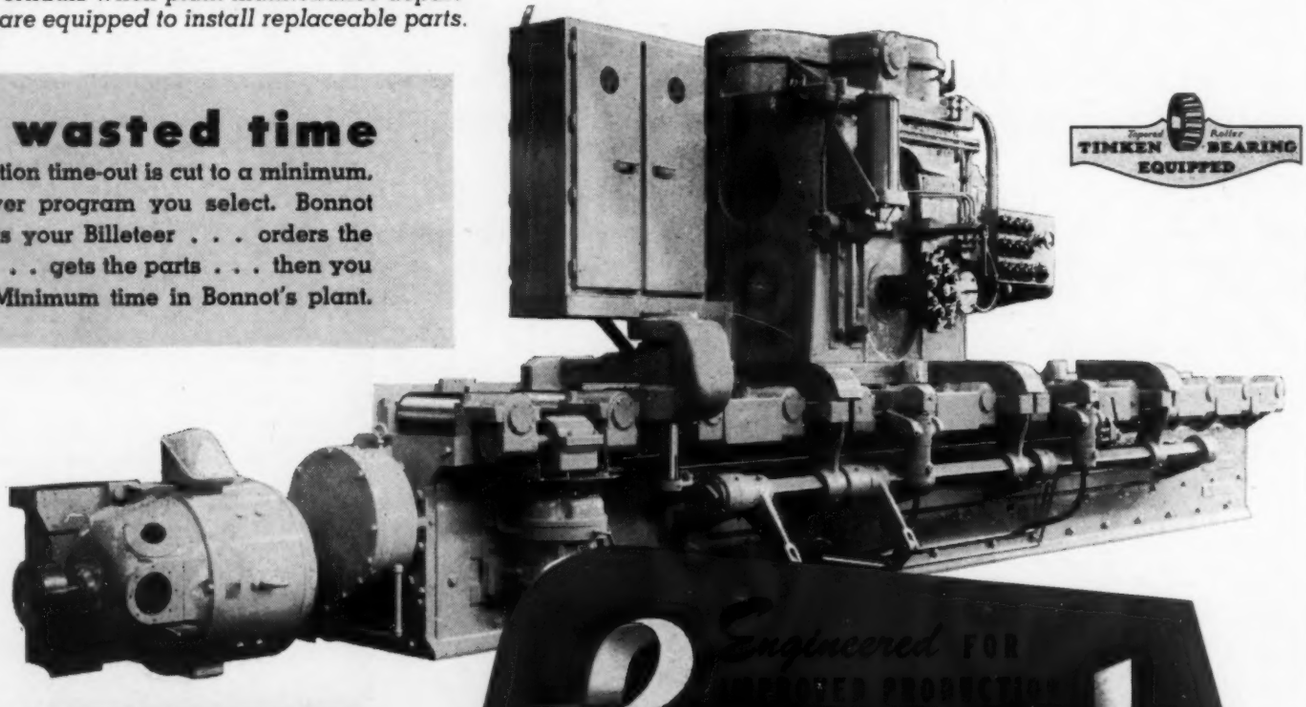
## 3. modernization program

*(includes programs 1 and 2)*

Build in new design roll table (for easy chip disposal) • incorporate flexible roll spacing and clamp arrangement (for chipping billets as small as 1¾ inches square —as short as 2 feet) • include accessible roll drive motor mounting (for reduced motor maintenance) • improve billet elevating mechanism • simplify manipulator and hydraulic cylinder mounting • improve "joy-stick" control.

## no wasted time

**Production time-out is cut to a minimum, whatever program you select. Bonnot inspects your Billeteer . . . orders the parts . . . gets the parts . . . then you ship. Minimum time in Bonnot's plant.**




Engineered FOR IMPROVED PRODUCTION

# Bonnot

THE BONNOT COMPANY

BUILDERS OF THE BILLETEER

CANTON 2, OHIO

**WRITE, WIRE OR TELEPHONE NOW**

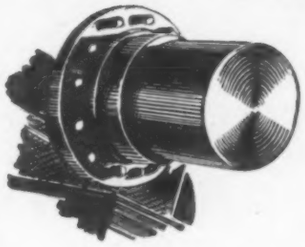
For complete details — and for a complete inspection of your Billeteer — just write, wire or call BONNOT. We are ready to start NOW.

**ADDRESS CORRESPONDENCE TO STEEL EQUIPMENT DIVISION**

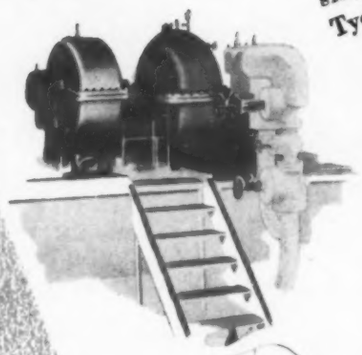
# FOR EVERY SERVICE CONDITION...

## You can count on

# TYCOL "ENGINEERED LUBRICATION"

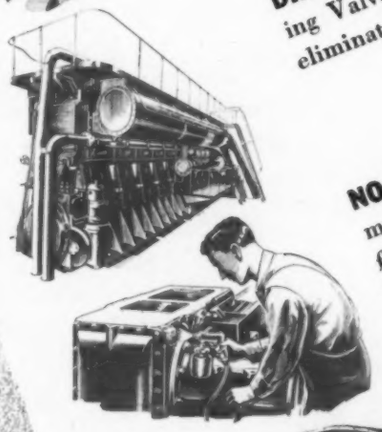


**EXTREME PRESSURE GREASE**—"Never a single bearing failure since we changed to Tycol E.P. Grease."



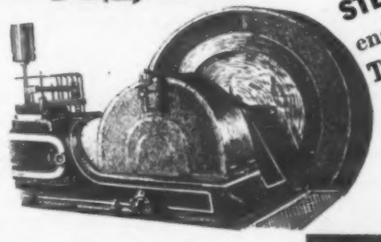
**TURBINE OIL**—"70,000 hours continuous operation . . . oil still in excellent condition."

**DIESEL OIL**—"No more trouble with Sticking Valves . . . costly delays and overhauls eliminated . . . engines giving better service . . ."



**NO-RUST-OLS**—Prevent rust formations on machines—small parts prior to assembly—and finished products. Usable at all temperatures by spraying, brushing, swabing or dipping.

**STEAM CYLINDER OIL**—"We saved 33⅓% engine lubrication costs when we changed to Tycol Cylinder Oil."



TYCOL

**• Results such as these are typical where Tycol lubricants are specified. Call, write or wire your nearest Tide Water Associated office for full details about the lubricant best suited to your needs.**

*Lubrication—"engineered to fit the job"*

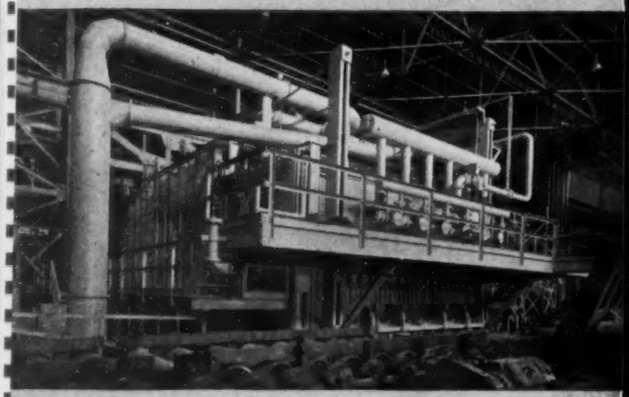
**Boston • Philadelphia • Pittsburgh • Charlotte, N. C.**

**TIDE WATER ASSOCIATED OIL COMPANY**

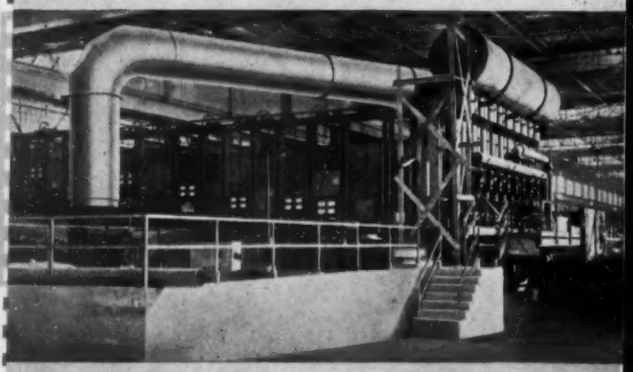
17 BATTERY PLACE · NEW YORK 4, N. Y.

# 'SURFACE' SERVES WITH HEAT

"Surface" one-way fired soaking pits



"Surface" slab heating furnace



"Surface" billet reheating furnace

"Surface" continuous heat treating furnaces for plate

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**Hundreds of installations, including the modern One-Way Fired Soaking Pits... Slab, Billet and Round Heaters ...Continuous and Batch Normalizers and Annealers — Muffle-type and Radiant Tube Fired, Controlled Atmosphere Furnaces... give outstanding proof of "Surface" acceptance wherever heat is used in the Steel Industry.**

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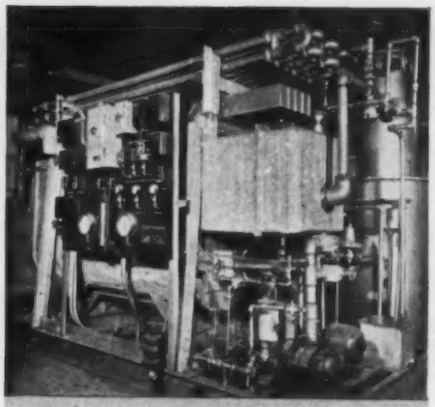
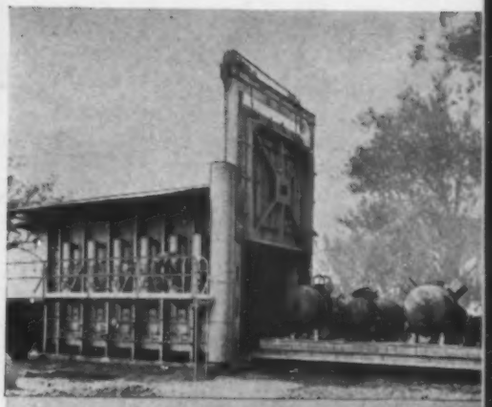
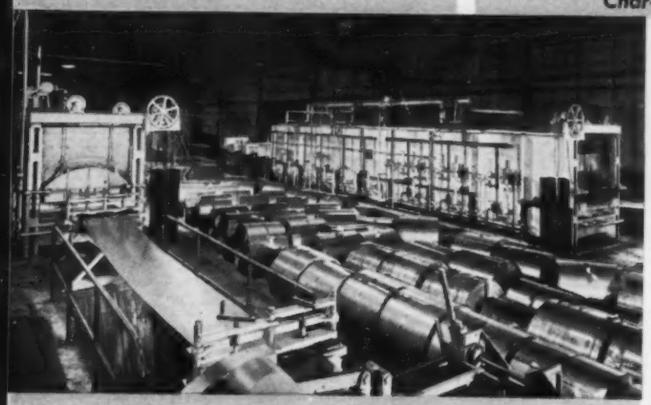
"Surface" rod annealing in pit type convection furnaces



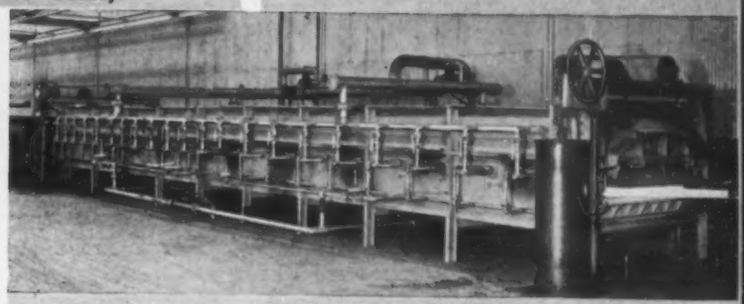
"Surface" prepared gas generating equipment (NX, RX, DX and Char-Mo Gases).



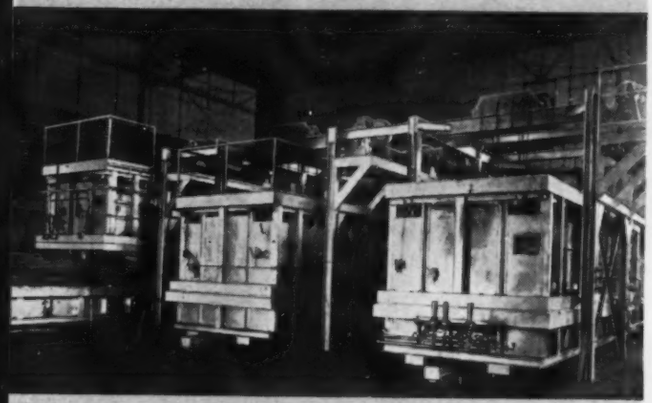
"Surface" stress relief furnace



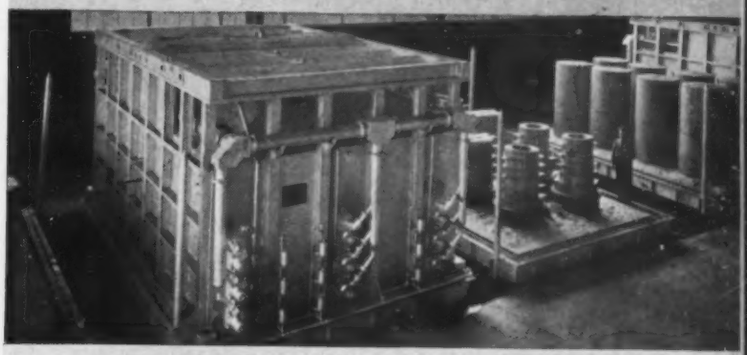
"Surface" continuous controlled atmosphere strip annealing and normalizing furnaces



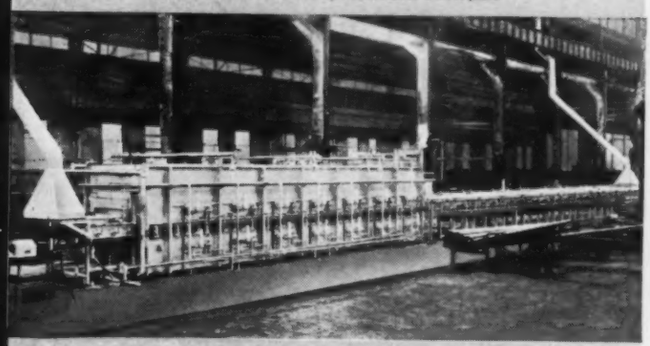
"Surface" wire patenting furnace



"Surface" high alloy rod and bar atmosphere annealing lift-cover with car-bottom furnace

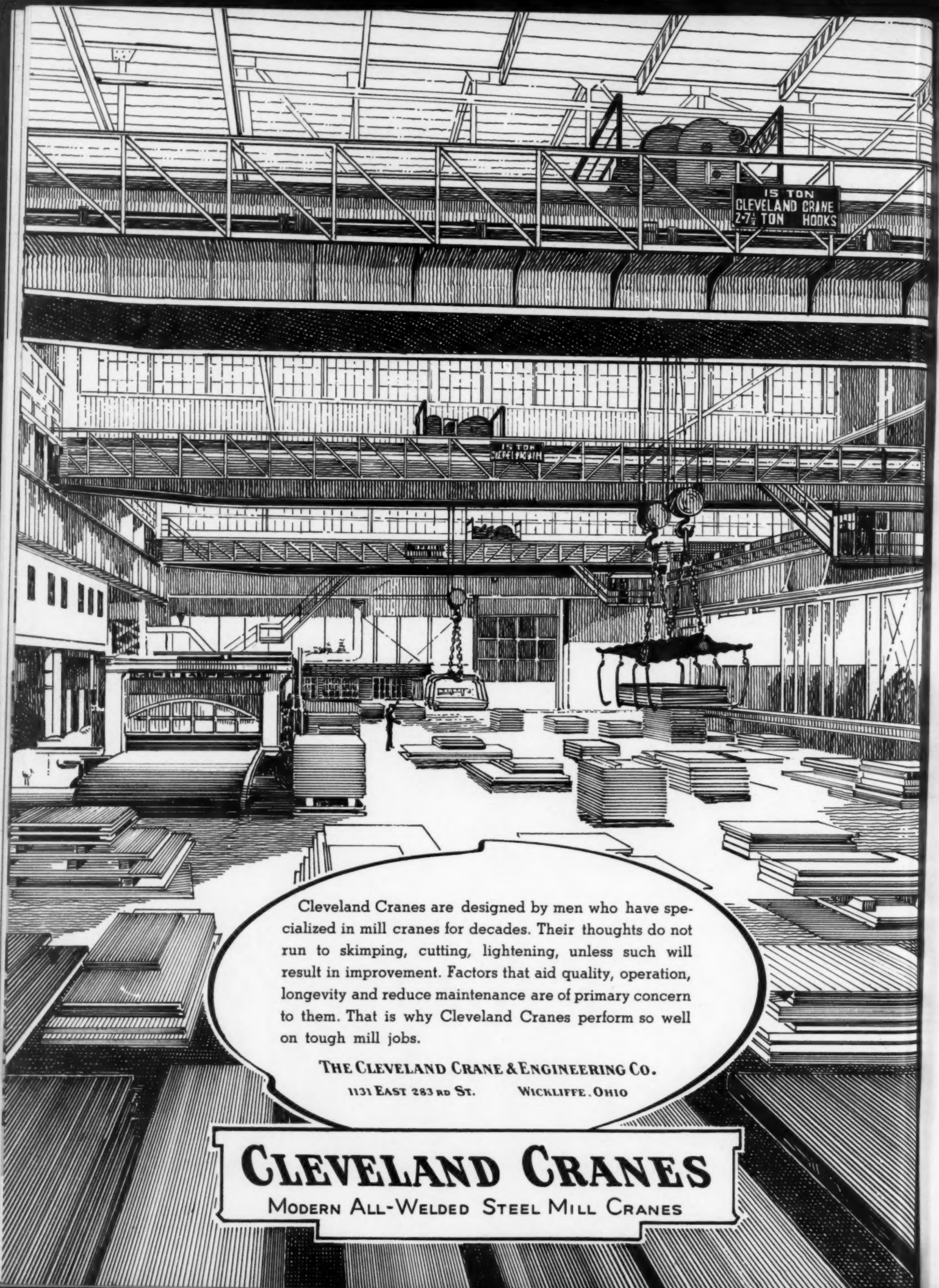


"Surface" controlled atmosphere coil and sheet annealing covers



"Surface" bright annealing and normalizing furnace for tubing

"Surface" controlled atmosphere wire and rod annealing furnaces

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# CLEVELAND CRANES

MODERN ALL-WELDED STEEL MILL CRANES

# Crops *and* Shorts

WE hear lots of conversation about a national income of 150 or 160 billion dollars, but so far we have reached this mark only upon borrowed money. There is probably little doubt in peoples' minds that national income must be high so that tax receipts are high so that we can service and reduce our national debt of 270 billion dollars. The majority of people probably recognize the necessity of wage increases in order to keep income up, but it must also be recognized that higher prices are necessary to pay the higher wages and still leave a margin of profit sufficient to invite capital investment. In short, perhaps we (and this includes Washington) should recognize that some inflation is inevitable. World War I left us a permanent inflation of about three-to-one, and although we will all suffer some as a result of further inflation beyond what we already have, perhaps it would bring some immediate industrial peace which would act to alleviate the shock and prevent an economic tail-spin of lost confidence.

The United States News recently headed its lead story thus: "Inflation is actively under way in this country right now. This inflation is occurring while people are still wondering if and when it is going to occur."

▲

LAST April we announced that the 1945 Yearbook of the Association of Iron and Steel Engineers might be delayed because of paper restrictions. We can now announce that printing of the Yearbook is proceeding, and it will be available about the usual time.

Incidentally the lifting of restrictions also made possible the larger trim size of this journal which you have probably noticed, as well as a better quality of paper than was formerly available. With the better paper our printing is regaining some of its former quality, but don't tell our printer that — he just gave us another boost in printing prices.

▲

ON the bus the other day, two neighbors could be heard vociferously planning their gardens for next spring — and here we are, just making up our minds whether to trim the shrubbery in the fall or in the spring. That's what comes of being such a meditative person.

THERE has been much talk, principally of the loose variety, about how the productive capacity of labor will increase to offset wage increases. Actually, various studies have shown that in many industries, the output per man-hour is actually lower than it was five or six years ago. Certainly, tomorrow's hoped for gains in productivity cannot be the basis for today's increase in wage rates. Let's have proof — not a pig in a poke.

▲

RAYMOND K. Moran, instructor in business administration at Kent State University, told his students "Americans are all capitalists at heart but most of us are just temporarily embarrassed for funds. This temporary embarrassment often lasts a lifetime."

▲

INDICATIVE of what can be expected in the way of elimination of the older, less efficient units in the steel industry is the announcement by Carnegie-Illinois Steel Corporation of the retirement of No. 1 and No. 2 open hearth shops at Homestead, No. 1 open hearth shop at Duquesne and four bessemer units at Edgar Thomson. This means a reduction of 2,405,000 tons per year in ingot production capacity, although the bessemer units will continue to be used to make scrap. Last year Carnegie-Illinois abandoned its Mingo works and sold its Farrell works to Sharon Steel Corporation.

▲

INDICATIVE of the way we have come to accept large figures in recent years is the tale about the lecturer who, in discoursing on the history of the universe, told the audience that the world would probably end in seven billion years.

"How long did you say?" came a terror-stricken voice from the audience.

"Seven billion years," the lecturer replied.

"Thank heavens!" exclaimed the voice, "I thought you said seven million."

▲

PICKETING in the steel strike seems to be particularly spotty in its amiability. At some plants, no one is permitted to pass in and out through the picket lines. At other plants, supervisors and maintenance men are allowed to pass in and out freely. In between these two extremes are all gradations of animosity, with some plants deeming it necessary to keep supervisors in the plant because of the unreliability of picketing policies.

In many cases, the companies serve hot coffee to the pickets. Probably the tops in fraternization was reached at Inland Steel, where the company provided a heated, lighted building for picket headquarters, as well as coke for salamanders, hot coffee, etc.

Equally wide variation is to be found in the character of the shut-downs accomplished in the various plants, ranging from clean jobs with everything shipshape and no foreign railroad cars in the plant to half-done jobs with equipment poorly laid up and foreign cars eating up demurrage at a startling rate.

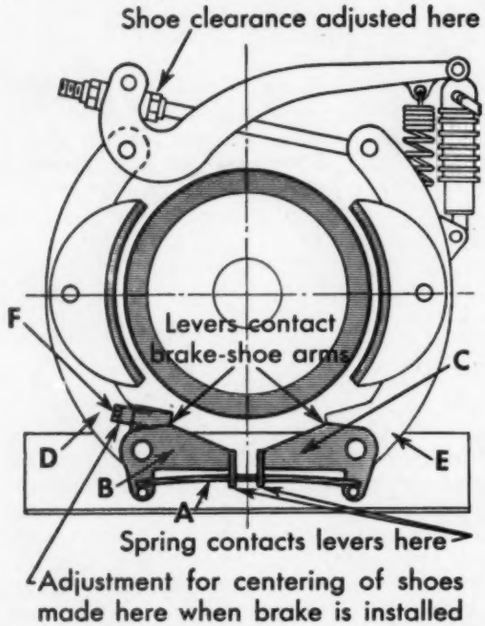
▲

PRESIDENT Truman, according to his message to Congress, wants higher wages and lower prices. Maybe that's what happened to the haberdashery.

# Wagner Self-Centering Device PREVENTS BRAKE-SHOE DRAG

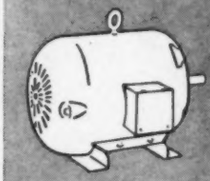
The new self-centering device on Wagner hydraulic bridge brakes prevents brake-shoe drag—thereby eliminating unequal brake-shoe wear and undue heating of the brake wheel.

It is simple in operation and requires no readjustments after installation. With the Wagner self-centering device, brake shoes remain centered irrespective of lining wear. It prolongs the life of the brake lining and reduces maintenance expense. Write for complete information. Wagner Electric Corporation, 6483 Plymouth Avenue, St. Louis 14, Mo.

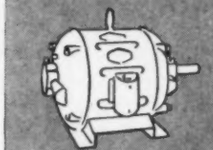


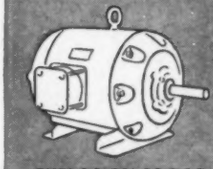

*Here's how it works:* The Wagner self-centering device utilizes the principle of the swinging door—in which a spring returns the door to the same starting point irrespective of direction of swing. A leaf-type spring (A) in the base of the brake actuates the ends of two levers (B and C) which bear equally against the two brake-shoe arms (D and E). The spring assures equal movement of both shoe cams, thus preventing either brake shoe from remaining in contact with the brake wheel. Brake shoes are originally centered at point (F) by means of a setscrew which is locked after the shoes have been accurately centered—after which the self-centering device keeps the shoes centered and prevents brake-shoe drag until relining is necessary, at which time recentering by means of the setscrew may be necessary.

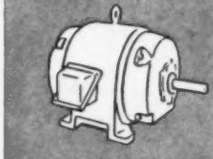
SQUIRREL-CASE MOTORS

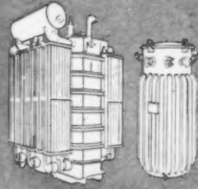

TOTALLY-ENCLOSED FAN-COOLED MOTORS

WOUND-ROTOR MOTORS


MULTISPEED MOTORS


EXPLOSION-PROOF MOTORS


SPLASH-PROOF MOTORS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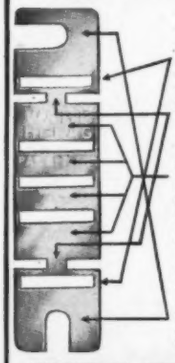

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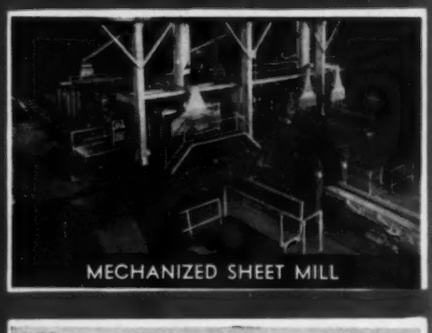

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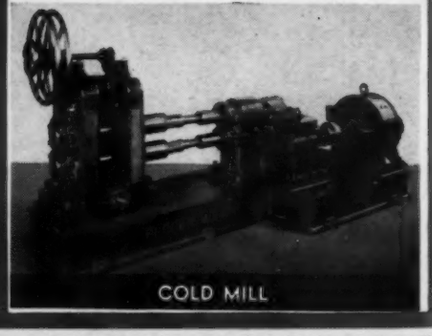

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# Iron AND Steel ENGINEER

FEBRUARY, 1946 VOL. XXIII NO. II

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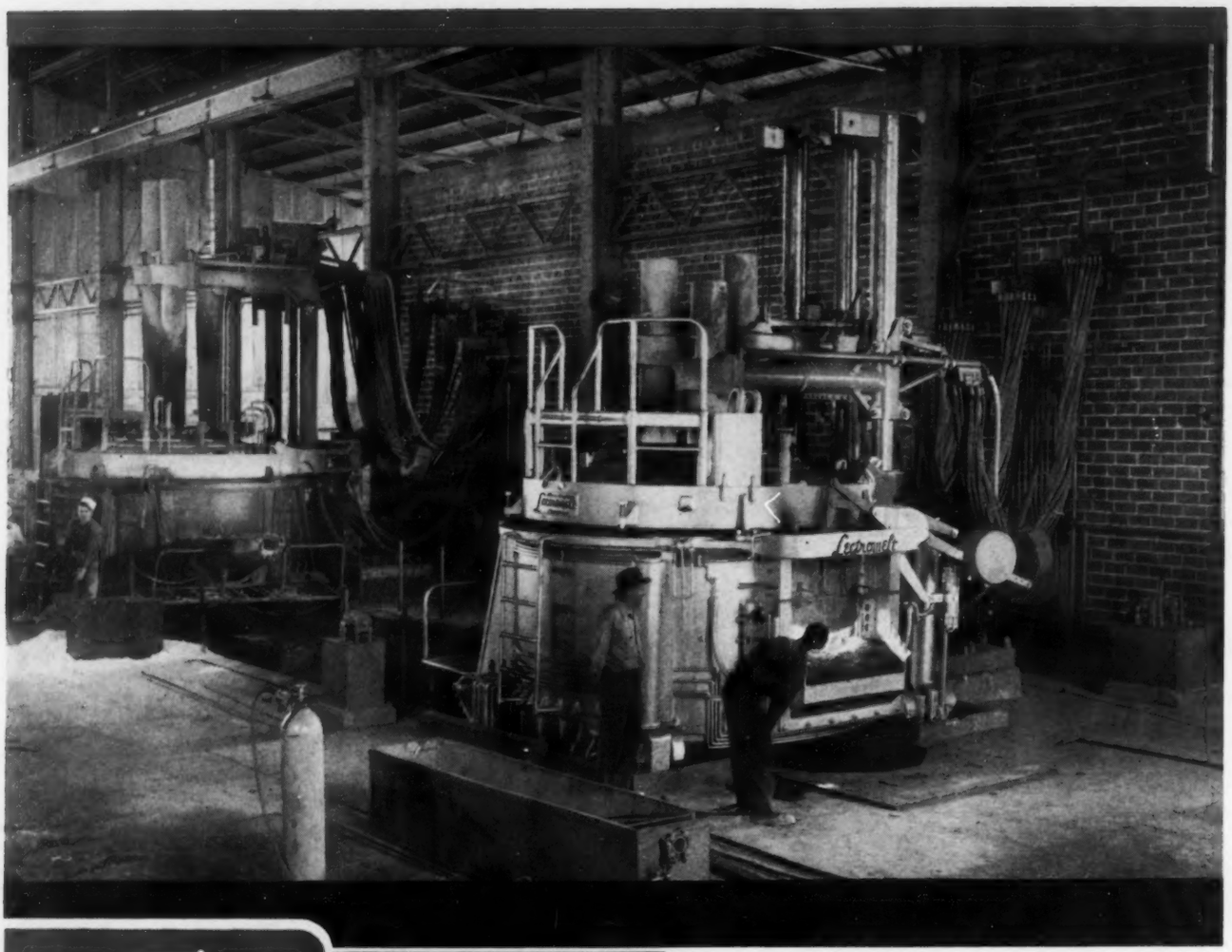

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PITTSBURGH LECTROMELT FURNACE CORPORATION
PITTSBURGH 30, PENNA.

# Recent Developments IN THE PYROMETRY OF Liquid Iron and Steel

*. . . . as more exacting requirements are placed on steel-making processes, knowledge of molten metal temperatures assumes greater importance . . . . experiments have so far led to the use of two types of immersion thermocouples for this measurement . . . .*

*by H. T. Clark*

RESEARCH AND DEVELOPMENT DIVISION

JONES AND LAUGHLIN STEEL CORPORATION

PITTSBURGH, PENNSYLVANIA

▲ THE measurement of the temperature of liquid metals, and in particular of liquid iron and steel, has engaged the attention of numerous investigators over a period of many years. The problem of attaining and controlling temperature in melting and refining furnaces can be attacked directly only if means for measuring the temperature are available. Thus the pyrometry of liquid iron and steel is a matter of concern to the operator, the metallurgist and the pyrometrist alike.

To the operator, the maintenance of a proper temperature in the bath of molten metal is important if his operations are to proceed in a satisfactory manner. In the case of the open hearth furnace, the range of temperature between the freezing point of low carbon steel and the softening point of the silica roof of the furnace is only about 200 F. The practical limits within which the operator must hold the temperature have been suggested as being considerably narrower:[1] the working range of such a heat being only about 120 F. Two of the causes of metal loss and increased steelmaking costs, i.e. ladle skulls and stool and mold stickers, are attributable in part to low and high metal temperatures. Furnace, ladle and mold life depends on other factors as well, but careful control of steelmaking temperatures should do much toward reducing the operating costs of the furnace.

Rates of reaction in the furnace, removal of impurities, particularly phosphorus, and efficiencies of deoxidizers are materially affected by the temperature of the bath and are primarily of concern to the plant metallurgist. He is likewise responsible for the ultimate quality of the steel as it may have been affected by steelmaking practices. Surface condition, segregation, and structure are undoubtedly among the temperature-sensitive properties of the ingot. It seems fair to assume that a considerable number of the unanswered questions facing the plant metallurgist today will be answered when accurate temperatures are obtained as a routine part of open hearth steelmaking.

The pyrometrist looks on the problem as a challenge to his ingenuity and skill in applying, adapting and inventing the necessary techniques and instruments for the work. Most of the pyrometers which he is accustomed to use fail at these high temperatures because they melt or dissolve, quickly become contaminated, or are not accurate enough in this range.

The importance of the problem is evident, and the

Presented before Pittsburgh Session of the A. I. S. E. Annual Meeting, Sept. 26, 1945.

interest in pyrometry of iron and steel is attested by the number of technical papers which have been published in the last fifteen years. It is the purpose of this paper to discuss the methods which have been and are being used, the results obtained, and to give the status of the work at the present time.

## THE PROBLEM

The problem, in essence, involves the measurement of temperatures in the range of 2600 to 3100 F with an accuracy of plus or minus 10 degrees. The metal is usually covered with several inches of slag which may be highly reactive and will therefore contribute to the early destruction of any equipment immersed in it. The slag also effectively blankets the metal from direct observation with an optical or radiation pyrometer. Working conditions in a steel mill indicate that the pyrometer should be mechanically rugged and that observations be taken with a minimum of interference with normal operations. Also, the costs, initial and maintenance, are of importance if the work is to be carried beyond the purely experimental stages.

Molten pig iron rarely attains a temperature above 2800 F in the runner of the blast furnace and temperatures of this iron in the ladle, mixer, and transfer ladle in the open hearth shop are perhaps one to 400 degrees lower. The carbon content of pig iron is essentially the saturation value and hence graphite protection tubes may be used successfully on immersion pyrometers. The graphite has good heat conduction and relatively long service life, the chief attack on the protection tube occurring at the interface between metal and air. Also, in the blast furnace runner, the metal surface is free of slag and radiation methods may be employed.

Measurement of the temperature of liquid, low carbon steel in a large basic open hearth furnace represents a most severe service test of pyrometric equipment. The temperatures range from 2800 to 3100 F, the slag and metal are highly reactive at these temperatures, the metal is covered with several inches of slag, there may be variations in temperature within the bath itself, and finally there is considerable physical difficulty in obtaining reliable temperature data on the open hearth floor.

## METHODS AND PROCEDURES

A number of independent methods have been used during the past few years with varying degrees of success. These may be classified for convenience as:

1. Thermocouple
2. Radiation
3. Miscellaneous

Considering the paucity of suitable materials for the elements of a thermocouple to be used up to 3100 F a surprisingly large number of combinations have been tried out in molten steel. Platinum-platinum rhodium, tungsten-graphite, tungsten-molybdenum, carbon-silicon carbide have been given consideration. Graphite-boron carbide, carbon-molybdenum carbide and carbon-tungsten carbide have been mentioned as having possible application. The thermocouple method is characterized by the fact, or more correctly by an assumption, that the elements of the couple are homogenous and that the one junction is heated to the temperature of the molten metal, while the other junction is maintained at some low, known temperature. The hot junction may fail to attain bath temperature if the depth or time of immersion is insufficient, if the couple is too well insulated from the bath or if heat is conducted away from the junction. Lack of homogeneity of the thermocouple materials in an intermediate temperature zone will give rise to parasitic electromotive forces which destroy the accuracy of the determination.

Radiation methods include the optical pyrometer, the two-color optical pyrometer, photoelectric instruments and thermocouple radiation units. The optical pyrometer is one of the standard instruments found in all open hearth shops for measurement of the temperature of molten steel, that it is not considered adequate is attested by the persistent search for a more reliable method. Other radiation instruments have been used in the open hearth shop with varying results. It should be noted that with radiation-measuring equipment it is not necessary that any part of the instrument itself reach a high temperature and that therefore, in theory at least, any temperature is measurable provided it is sufficiently high to emit adequate amounts of radiant energy.

The properties of matter, in general, change with temperature and it is to be anticipated that a number of miscellaneous methods could be developed for measuring the temperature of molten steel. In the "Seventh Report on the Heterogeneity of Steel Ingots," of the Iron and Steel Institute published in 1937[2], the liquid steel temperature sub-committee suggested the following methods which were considered by it: (1) density, (2) surface tension, (3) mechanical properties, (4) thermal conductivity, (5) magnetic properties, (6) thermal expansion, (7) heat capacity or specific heat, (8) vapor pressure, (9) electrical resistance, (10) velocity of sound and (11) ionic emission. The committee concluded that, while not overlooking the possibility of developing a new principle of temperature measurement, it would concentrate on the adaptation of existing methods.

This decision on the part of the English pyrometrists placed a restraint on their development work in these new and untried fields but unquestionably expedited the evolution of a thermocouple method finding wide acceptance in England and some use here.

It is not enough that the measuring device respond to high temperatures. The response must be reproducible and it must be great enough to be measured with the desired degree of precision. Few other limitations need be placed on an instrument for laboratory use. It does not have to be economical, it may require considerable maintenance and it may be difficult to calibrate. However, a device for routine mill use has to satisfy all these requirements, including accuracy.

## REVIEW OF METHODS

A relatively few methods have received most of the attention of investigators and it will perhaps be most profitable to consider these in turn, giving references to the original articles and including results from our own investigations where they are pertinent.

*Tungsten-molybdenum thermocouple* — The high melting points of tungsten and molybdenum, about 6000 F and 4600 F respectively, suggested these metals as thermocouple elements for molten steel. Osann and Schroder[3] in 1933 described a W-Mo thermocouple for electric furnace use and Schroder[4] wrote another article describing some results obtained with the instrument in basic open hearth furnaces. The wires were protected from steel and slag by an inner tube of sillimanite and an outer tube of silicon carbide, which was later changed to a sintered corundum tube. The couple was immersed to a depth of 16 inches and a steady reading was obtained after 100 seconds immersion. Leiber[5] in 1937 did some further work with the W-Mo couple and indicated that he was able to obtain repeated measurements with accuracy and safety.

Several features of this thermocouple are of interest. The emf-temperature curve is shown in Figure 1. At 3000 F the reading will be only about 2.5 millivolts. More important than the total reading, assuming that an indicating instrument of sufficient accuracy for a total reading of this magnitude is available, is the change in millivolts for a given change in temperature. In the range of steelmaking temperatures, this amounts to about 0.375 millivolts per 100 degrees F as compared with 0.65 millivolts per 100 F for a platinum-platinum 10 per cent rhodium couple. Leiber doubled the output of his elements by using two W-Mo couples in series.

Formander and Omberg[6] in 1939 carried out a series of measurements but were somewhat pessimistic about the value of the results. They attained temperature in 2½ to 3 minutes and the life of their couple was about 6 heats. The temperatures were not in agreement with the estimates of the melters nor did they show any relationship with the behavior of the steel in the molds.

The immersion time required for a reading is long by present standards and the life of the couple is short, three trials being indicated as a maximum for one couple. The elements of the couple easily withstand any steelmaking temperature but the necessity for protecting them against damage by oxidation and water vapor and by solution in the steel requires the use of refractory protection materials which are relatively vulnerable to attack by the slag and steel, to mechanical damage and to heat shock fracture. Calibration of each lot of wire would probably be required. With the short life expectancy of the couple, it would be quite uncertain whether or not a given immersion would result in a satisfactory reading and, in any case, maintenance would be high.

*Tungsten-graphite thermocouple*—The tungsten-graphite thermocouple was described by Watson and Abrams[7] in 1928. In their case a tungsten wire under tension was held along the axis of a graphite tube closed at the lower end by a graphite plug which supported the tungsten wire. The graphite tube is protected by a suitable outer refractory tube. Holtby[8] carried out some further work with this thermocouple using a smaller assembly in order to decrease the heat capacity of the unit and make it suitable for use in small ladles of iron or steel. His earlier form of the instrument was conventional, with the tungsten rod apparently under compression and the cold junction water cooled. In a later version, he used separated tungsten and graphite elements which were quite small and of low heat capacity; the electrical contact at the hot junction was made through the molten metal.

The tungsten-graphite thermocouple has several features of interest. Among its advantages are: (1) an emf of reasonable magnitude — about 38 millivolts at 3000 F as is to be observed in Figure 2; (2) good sensitivity about 1.25 millivolts per hundred degrees at 3000 F; (3) relatively simple design, the graphite protection tube for the tungsten forming the other element; and

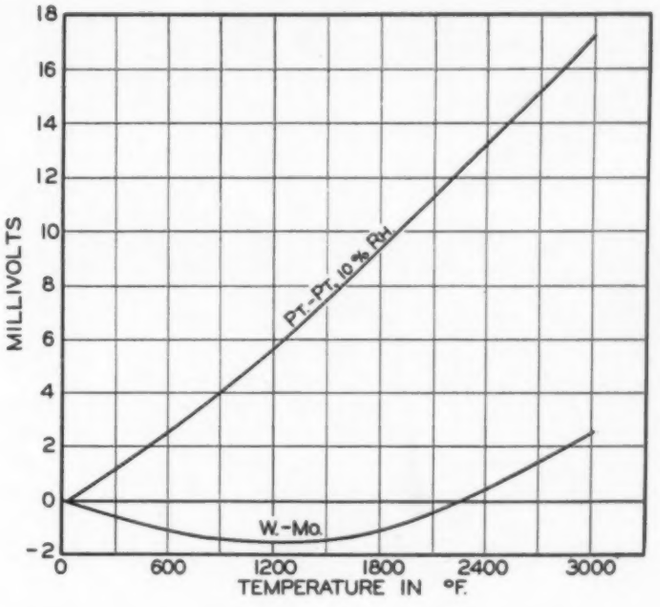


**Figure 1 — Electromotive force — temperature curve for the tungsten-molybdenum thermocouple. Also shown for comparison is a similar curve for the platinum-platinum, ten per cent rhodium thermocouple.**

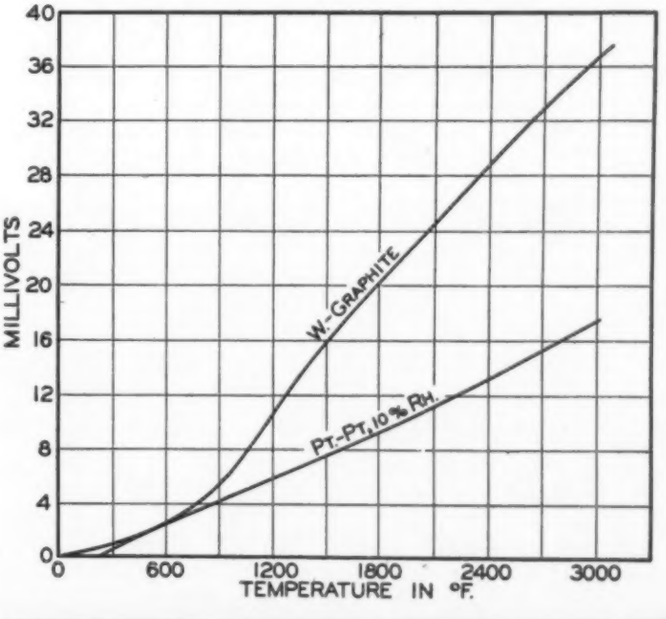


**Figure 2 — Electromotive force-temperature curve for the tungsten-graphite thermocouple which generates a larger emf than the platinum couple at high temperatures.**

(4) the reading is only slightly affected by reasonably large changes in cold-junction temperature. As disadvantages: (1) the graphite must be protected from attack by lower carbon iron or steel; (2) the couple is not rugged and must be handled carefully; (3) there is some uncertainty as to the calibration of the couple; and (4) water cooling is inconvenient and possibly dangerous on some applications.

Some experiments with the tungsten-graphite couple were made in our blast furnace iron and slag using a ⅛ inch tungsten rod under a slight compression stress and an unprotected graphite tube with a water cooled head. The tungsten rod was rigid enough to require no insulators, one end being seated in a ⅛ in. hole in the graphite tube and the other mounted on springs to maintain a uniform thrust. Water and electrical leads were taken out through the handle. A length of pipe, slightly longer than the couple, was threaded into the metal head to protect the couple when not in use. This couple in use in the blast furnace runner is shown in Figure 3.

**Figure 3 — The tungsten-graphite thermocouple in use at the blast furnace showing the relatively small assembly required.**

▲

**Figure 4 — Silicon carbide-carbon thermocouple in use at the blast furnace. In this case, it is being checked against a platinum thermocouple mounted on the same stand in the blast furnace runner.**

The couple was easy to handle and, with proper care, could be used for a considerable number of immersions in pig iron before the graphite tip had to be replaced. It was found, however, that there were some anomalies in the temperatures obtained by this method and it is likely that the causes of these were one or both of the following: (1) the different lots of tungsten and of graphite gave somewhat different results and (2) moisture content of the graphite affected the reading very materially. This latter condition was extreme when a leak developed in the water cooled head and water was present inside the graphite. The readings rose to quite high values and it was only after thorough baking of the graphite that reasonable readings could again be obtained.

If the body of the couple is exposed to considerable radiation during the immersion, water cooling seems essential to keep the cold ends of the graphite and tungsten at the same temperature. However, Holtby developed compensating leads of high and low carbon steel wire and was able to use an air-cooled thermocouple head on a portable unit.

*Carbon-silicon carbide thermocouple* — The carbon-silicon carbide thermocouple, developed by Fitterer,[9] has been used to measure the temperature of iron and steel both here and abroad.[10] This thermocouple is quite unusual in that the electromotive force generated at 3000 F is almost one half of a volt. This corresponds to about 17 mv per 100 degrees.

The one element of the thermocouple is a silicon carbide rod set coaxially in a closed-end graphite tube which forms the other element. The upper ends of the elements are generally water cooled to form the cold junction.

There are several points of similarity between this and the tungsten-graphite thermocouple. Neither is affected by rapid changes in temperature and both may be used at the highest temperatures ever encountered in a steel plant. The graphite sheath in both cases must be protected from attack by slag and metal and both thermocouples are mechanically fragile, with the Fitterer couple using brittle materials for both elements. The protection of the graphite with clay or a clay-graphite mixture tends to retard heat flow and results in prolonged immersions unless the couple is preheated in an auxiliary furnace. The physical dimensions of the Fitterer thermocouple are somewhat greater than those of the tungsten graphite couple because of the use of a ⅝ in. silicon carbide rod in place of a wire of tungsten.

Several hundred readings have been made with the Fitterer couple in our pig iron and under the circumstances of the test the couple functioned with a reasonable amount of maintenance and repair. Figure 4 shows the arrangement used in the early work for checking with a platinum thermocouple in the blast furnace runner. A permanent mounting with retractable gear was later constructed in the cast house to prevent breakage due to handling; and service in pig iron of 4.5 per cent carbon minimized erosion of the graphite sheath. The accuracy of the temperature readings, as

checked occasionally against a platinum thermocouple was fairly good in most instances.

With the permanent installation, the couple assembly was exposed to rather severe conditions of temperature and humidity and some of the results were of questionable accuracy. On one occasion, a water leak developed inside the couple and the hot junction became moist. The next reading was very low, and reasonable readings were not again obtained until the couple had been baked in a high temperature furnace. It is to be noted that the effect of moisture in the case of the silicon carbide-carbon thermocouple is opposite to that indicated for the tungsten-graphite couple; this is understandable since the graphite has opposite polarities for the two thermocouples.

*Platinum-platinum rhodium thermocouple* — The platinum-platinum 10 per cent (or 13 per cent) rhodium thermocouple has been used as the standard pyrometer for measuring steel temperatures, and all of the other methods have been judged by how well they duplicated the results obtained with it. Investigators, who had only a secondary interest in the methods for measuring temperature, may have used the platinum thermocouple exclusively but make only passing reference to the fact in their published papers. To offset a considerable cost of the elements, the wire is thermoelectrically standardized and may be used to temperatures of 3100 F, the melting point of platinum is 3191F. No second method need be kept available to calibrate the platinum couple; for calibration is necessary only when it is suspected that the couple is contaminated and then the calibration is generally made against a new platinum couple.

The conventional assembly for the platinum thermocouple possesses many of the same undesirable features of the methods already discussed. The elements must be protected from attack by reducing gases and are therefore enclosed by a gas-tight refractory tube. This tube in turn is protected against solution in the slag by a sheath of graphite, clay or other suitable material. Immersion of graphite, which is the best heat conductor of the common protection tubes, into molten low-carbon steel results in its rapid solution and hence a protecting wash of clay is sometimes used.

These several protective layers cause the response of the couple to be sluggish, increase the bulkiness of the unit, and the sheaths are made up of brittle materials which cannot withstand rough handling. Also, the ceramic inner protection tube is subject to heat shock and may break at any time that the temperature is changing rapidly. A fracture of this protection tube while the unit is hot results in destruction of the thermocouple.

To summarize, Table I gives the electromotive force generated by each of the thermocouples discussed above at 3000 F and the change in emf from 2900 F to 3000 F. Variations in some of these values are to be expected depending on the sources of the materials.

**TABLE I**

| Thermocouple | Emf at 3000 F mv | Emf per 100 F mv |
|---|---|---|
| Tungsten-molybdenum | 2.5 | 0.375 |
| Tungsten-graphite | 38.0 | 1.25 |
| Carbon-silicon carbide | 480.0 | 17.00 |
| Platinum-platinum, 10% rhodium | 17.25 | 0.65 |
| Platinum-platinum, 13% rhodium | 19.4 | 0.75 |

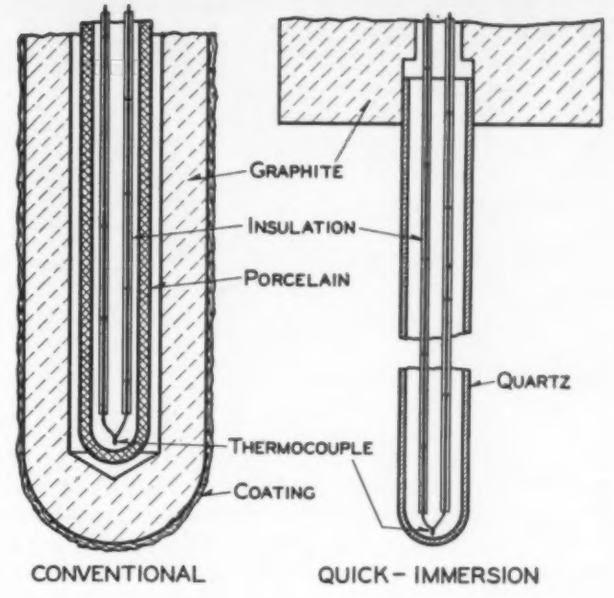


**Figure 5 — Platinum thermocouple showing on the left the conventional and on the right the quick-immersion protection assemblies.**

*The quick-immersion platinum thermocouple technique* — Recognizing the advantages of a platinum thermocouple, English metallurgists a few years ago attempted to eliminate the undesirable features of the method and, as a result, the quick-immersion technique was worked out for use in steel furnaces, furnace runners, ladles and molds. The method has been reported in a number of British articles[12] and it is indicated that it is being used extensively in the English steelworks. More recently the method has been adopted by the Rustless Iron and Steel Corporation for use in the electric furnaces in their Baltimore plant.[13]

In this case, the platinum is protected from the slag and steel by only a thin quartz tube over the hot junction and the two to three inches of the couple adjacent to the hot junction. Figure 5 compares graphically the conventional method of protecting the thermocouple and the method used in the quick-immersion technique. The remainder of the couple in the English version is protected by steel pipe inside diatomite brick while in the Rustless couple a graphite sheath covers the steel protecting the couple itself while the main body of the assembly consists of two concentric pipes with the space between them packed with insulating rock wool. The platinum couple terminates in the head and is connected to compensating lead wire at that point. Provision is also made in this head for extra platinum wire which is unrolled if the lower end is damaged or destroyed in the molten steel. A new hot junction is formed by welding.

An immersion time of 15-30 seconds is considered normal for a satisfactory reading and for an immersion of this duration either method of insulating the as-

sembly from radiant heat appears adequate. The door of the furnace is open during an immersion and a radiation shield is frequently used to protect the operator. The assembly is fragile and has to be handled with care to prevent breakage of the graphite and quartz tubes.

The question of variations in temperature within the bath has been considered using the quick-immersion thermocouple method.[14] Readings were taken at various locations in the furnace and at various depths in the bath. An active open hearth bath was found to be quite uniform in temperature, variations becoming larger as the bath became more quiet. It has been indicated that, in the majority of cases, a temperature taken in an open hearth bath at a selected standard position is likely to be representative of the mean temperature within about plus or minus 18 degrees F.

The outstanding advantages of this method of measuring steel temperatures lie in the use of a platinum-platinum, rhodium thermocouple which is standardized thermoelectrically and in the short immersions during which a minimum mass of the assembly is required to attain the temperature of the molten steel. In the earlier versions of thermocouples, as much as several pounds of protection tubes had to be heated to the maximum temperature for accurate results. The renewal of the quartz tube constitutes one of the chief maintenance expenses for the quick immersion unit, but such a procedure practically assures a good reading for each immersion and the rest of the assembly has a relatively long useful life.

## RADIATION METHODS

Determination of temperature by radiation from a hot body involves the use of a pickup unit sensitive to these radiations. The oldest unit of this kind is the human eye — at first unaided, later assisted and protected by filters which reduce the intensity and alter the special distribution of the light. Finally, a comparison source was introduced and the radiation from the two bodies was matched at a specific wavelength.

The other radiation energy pickups most generally used are, in addition to the human eye, thermocouples or thermopiles and the various forms of photoelectric cells. In principle, of course, any instrument of use in thermometry can be employed in a radiation instrument since, except for photosensitive devices, the radiant energy is converted to heat and the rise in temperature is a measure of the temperature of the original source. The choice is limited generally by the requirements of high speed and reproducibility. Thermopiles with a small heat capacity and photoelectric cells have met these requirements with a considerable degree of success.

*Optical pyrometer* — The optical pyrometer has been used to obtain the temperature of an open hearth bath by utilizing accessory equipment to expose either the clean metal surface or a second surface at the same temperature. A closed-end refractory or graphite tube below the metal surface,[15] an open-end tube immersed in the steel and kept clear by an air stream,[16] and the slag itself all offer a surface which may be observed with an optical pyrometer.

Most frequent use is made of the optical pyrometer for observing the temperature of the steel during tapping and teeming. Observations are generally made on the clean metal surface if possible and an emissivity of .4 is then used to establish the correction factor. Blaurock,[17] on the basis of extensive work with optical pyrometers, discusses the errors of the method and the steps which can be taken to improve the accuracy of measurement. Cook[18] describes a system of temperature control of the open hearth furnace based on optical pyrometer readings of the steel at tapping and teeming. Wenzl and Morawe[11] sighted an optical pyrometer on the bright areas of the metal stream and found a quite small correction factor when the temperature was compared with platinum thermocouple temperatures. Sighting on the dark portions of the stream gives readings corresponding to an emissivity for steel of approximately .4.

The objections to this method include: (1) errors of considerable magnitude if dust and smoke intervene; (2) data in the form of a post-mortem of the heat when tapping temperatures are obtained; (3) uncertainties as to the emissivity of the surface under observation; and (4) no objective record of the reading for reference. The advantages are simplicity, speed, and the fact that no part of the measuring equipment is at the temperature of the steel, with the exception of the case where a closed-end tube is used.

*Two-color pyrometers* — A correction must be made to the temperature reading obtained with an optical pyrometer due to the emissivity factor and, since this factor is different for different radiating surfaces and also changes with temperature, the selection of a correction value is frequently difficult. In an effort to obtain the true temperature optically, several investigators have developed two-color pyrometers. These instruments supply readings for two colors in different spectral regions, and the ratio of these two readings is a measure of the temperature.

Versions of two-color pyrometers using either optical means or photoelectric cells have been described by Russell, Lucks and Turnbull,[19] by Malpica,[20] and by Virasoro and Benaz,[21] while an optical instrument with a wedge-shaped bichromatic transmission filter was designed by Naeser[22] several years ago. This last instrument differs from the others in that both a brightness and a color match is made against a comparison lamp so that true and apparent temperatures are obtained by the settings of the grey and colored wedge filters. It was said before the war,[23] that the pyrometer of Naeser found considerable use in Germany in industrial plants and that the temperatures obtained with it were used for control of steelmaking. Discussion with some pyrometrists in this country has indicated considerable difficulty in obtaining a reliable setting of the instrument and that the disappearing-filament type was to be regarded as superior. No data on the use of the other two-color pyrometers in the steel mill are available.

*Photo-electric pyrometers* — In addition to the two-color photoelectric pyrometers mentioned above, the use of photoelectric cells for measuring high temperatures such as those encountered in steelmaking has been described by a number of investigators.[24]

Quoting Land, "Although photo-electric cells have been used by several workers for temperature measurement, the calibration appears to be more or less em-

pirical. Usually the cell current has been compared with readings taken with an optical pyrometer and the logarithm of the cell current plotted against the logarithm of the absolute temperature. Few or no quantitative data have been published on the errors which may arise from different sources."

The photoelectric cells used for molten steel temperatures are generally of the barrier-layer type which generate an electromotive force when exposed to light. Their spectral sensitivity is roughly the same as that of the human eye and their response corresponds to a change in cell current proportional to the twelfth or thirteenth power of the absolute temperature. Temperatures below 2000 F are not normally measured with this type of pickup since the response is quite low at lower temperatures, but at molten steel temperatures the change in cell current with a change in temperature is so large that a very open scale of temperature results. It has been pointed out[16] that, "On a temperature scale covering the range from absolute zero to 3100 F, the last two hundred degrees from 2900 to 3100 F extend over slightly more than one-half the entire width of the record."

*Total radiation methods* — Total radiation pyrometers have been employed extensively for surface measurements of hot solids and for furnace measurement and control but references to their use for liquid iron and steel are limited. Koch and Schuh[25] used a total radiation pick-up sighted on the closed end of a refractory tube which was submerged in molten cast iron. It is necessary in such an assembly to purge the air within the tube of smoke and fumes which would lower the readings. The tube can be used to complete destruction since no equipment is exposed to damage upon failure of the tube. The method has the disadvantage that a considerable mass has to be heated to the temperature of the bath so that the problem of an adequate refractory material is again paramount.

*Open-end tube immersion pyrometer* — Another approach to the measurement of bath temperatures is embodied in the open-end tube, immersion pyrometer which is being used with both photoelectric cell and total radiation pickups. Its principle is described in patent No. 2,020,019 and its use as a photoelectric pyrometer described by Sordahl and Sosman[16] and as a total radiation instrument by Bradley[26] and Martin.[27]

This immersion pyrometer, as the name implies, is a steel pipe open at the one end which is immersed in the steel bath. Compressed air, at sufficient pressure to keep the inside of the tube free of steel, is blown through it and either an optical pyrometer, photoelectric cell or a total radiation pickup sighted on the molten steel through the hole. A recent design of an open-end tube pyrometer, using a total radiation element, is shown in Figure 6. It has been found that the pyrometer can be immersed several hundred times in the molten steel before replacement of the outer tube becomes necessary. When used in conjunction with a high speed recorder, a reading can be taken with a 5-10 second immersion and little maintenance is required if the equipment is handled normally.[28]

Calibration must be made of the entire unit since the size of the hole, the distance between hole and radiation pickup as well as the intrinsic sensitivity of the latter all affect the recorder response. This is not true, of course, when the optical pyrometer is employed. The photoelectric cell may be calibrated by a standard lamp, and both it and the total radiation pickup by a furnace at some known temperature. However, the accuracy of a reading of steel temperature depends as well on the emissivity of the steel in the cavity opened up by the air stream and therefore probably the best practical calibration would be against a standardized platinum thermocouple in the same bath.

**Figure 6 — The open-end tube immersion pyrometer in use at the open-hearth furnace. The pyrometer is thrust through the wicket hole and forced down through the slag into the molten metal where a reading is obtained in a few seconds.**

The open-end immersion pyrometer is characterized: (1) by not requiring that any part of the measuring equipment attain the temperature of the steel; (2) by exposing continuously a fresh surface of the steel to the radiation receiver; (3) by being quite rugged and not readily subject to mechanical damage; and (4) by low operating and maintenance costs.

Further development of the open-end tube, immersion pyrometer as a total radiation instrument has been undertaken, and work has progressed to a stage where it is felt that considerable reliance can be placed on the results.

## GENERAL CONSIDERATIONS

The physical chemistry of steelmaking has received a great deal of attention in the last few years and physical chemists are acutely aware of the necessity for accurate liquid metal temperatures if their studies are to be of the greatest benefit to the industry. It has been stated[29] that "One of the most pressing needs in the development of the open hearth process, even up to the present time, has been an entirely satisfactory means of measuring accurately the temperature of the steel in the furnace. In spite of the high level of temperature in steelmaking operations, in the neighborhood of 3000 F (1650 C), good steelmaking practice requires that heats be tapped and teemed very close to the desired or specified temperatures for all particular grades of steel concerned. A variation of as little as plus or minus 25 F (15 C) from the desired temperature may at times be very evident in the quality of the product. In order to detect such a variation in temperature, the precision of the physical measurement of temperature must be

within about 0.5 per cent. This is about the best that can be expected of temperature measurements at this level under ideal laboratory conditions. The difficulty, then, is that the range of significant variations in temperature from the standpoint of practice is not much greater than our ability to detect differences in temperature with certainty by temperature-measuring devices."

It is interesting and suggestive that the two methods of measuring bath temperatures being given serious consideration at present — the quick-immersion platinum thermocouple and the open-end tube immersion pyrometer — have employed the available materials and instruments and have taken advantage of their potentialities. The platinum thermocouple is an accepted means of measuring high temperatures, and the photoelectric and total radiation pickups apparently permit of highly reproducible results when used under propitious conditions. Present refractories do not long withstand the erosive action of furnace gases, slag and metal, and they are subject to breakage by heat shock and mechanical blows; hence the one pyrometer dispenses with refractories entirely while the other reduces the amount required to a minimum. It should not be overlooked that steel temperatures can be read by a number of other instruments if the investigator can afford to go to the trouble of building and maintaining the equipment. These two pyrometers, however, are designed for routine use in the steel mill and to meet the requirements of practicability as well as those of accuracy and reliability. It seems fair to predict that they will find an increasing field of usefulness in the open hearth and electric furnace shops as more exacting requirements are placed on steelmaking processes. Nevertheless, we must not lose sight of suggestions, such as those of the British a few years ago, that changes in physical properties other than those considered up to the present can be used for measuring temperature. It may well be that some of the technical developments of the war years will make practical the use of these physical properties of the steel for the measurement of its temperature while in the furnace, ladle or mold.

## BIBLIOGRAPHY


1. Sosman, R. B., *Pyrometry of Solids and Surfaces*, A. S. M. 1940, pp. 72-74.
2. *Seventh Report on the Heterogeneity of Steel Ingots*, Iron and Steel Institute, 1937, p. 216.
3. Osann, B. and Schroder, E., Archiv f.d. Eisenhuttenwesen, Vol. 7, 1933, pp. 89-94.
4. Schroder, E., Stahl und Eisen, Vol. 53, 1933, pp. 873-881.
5. Leiber, G., Archiv f.d. Eisenhuttenwesen, Vol. 11, 1937, pp. 63-66.
6. Fornander, S. and Omberg, T., Jernkontorets Ann., Vol. 123, 1939, pp. 527-544.
7. Watson, H. L. and Abrams, H., Transactions American Electrochemical Society, Vol. 54, 1928, pp. 19-36.
8. Holtby, F., Transactions American Foundrymen's Association, Vol. 47, 1939, pp. 854-871.
   Holtby, F., Transactions American Society for Metals, Vol. 29, 1941, pp. 863-75.
9. Fitterer, G. R., Transactions A. I. M. E., Vol. 105, 1933, pp. 290-301.
   Fitterer, G. R., Transactions A. I. M. E., Vol. 120, 1936, pp. 189-216.
   *Fitterer Pyrometer for Measuring Liquid Steel Temperatures*, The Iron Age, Vol. 140, July 22, 1937, pp. 38-40.
   Fitterer, G. R., Instruments, Vol. 13, 1940, pp. 157-160.
   Fitterer, G. R., *Temperature, Its Measurement and Control in Science and Industry*, A. I. P. 1941, pp. 946-957.
10. Guthmann, K., Stahl und Eisen, Vol. 60, 1940, p. 232.
    *Seventh Report of Heterogeneity of Steel Ingots*, Iron and Steel Institute 1937, pp. 215-221.
11. Wenzl and Morawe, Stahl und Eisen, Vol. 47, 1927, pp. 867-71.
    Joseph, T. L., Transactions A. I. M. E., Vol. 125, 1937, pp. 204-245.
    Watson, H. L., See reference 7 above.
    Holtby, F., See reference 8 above.
12. Schofield, F. H., *Seventh Report on Heterogeneity of Steel Ingots*, Iron and Steel Institute, 1937, pp. 222-238.
    Schofield, F. H. and Grace, A., *Eighth Report on Heterogeneity of Steel Ingots*, Iron and Steel Institute, 1939, pp. 239-264.
    Schofield, F. H. and Grace, A., *Temperature, Its Measurement and Control in Science and Industry.*, A. I. P. 1941, pp. 937-945.
    *Third Report of Liquid Steel Temperature Sub-Committee*, Journal Iron and Steel Institute, Vol. 145, 1942, pp. 213-243.
    Freeman, R. W. S., Canadian Metals and Metallurgical Industries, Vol. 7, 1944, pp. 23-25.
13. Weitzenkorn, L. F., Proceeding of the Second Conference, Electric Furnace Steel, A. I. M. E. 1944, pp. 143-149.
14. Oliver, D. A. and Land, T., Journal Iron and Steel Institute, Vol. 145, 1942, pp. 245-277.
    Blast Furnace and Steel Plant, Vol. 30, 1942, pp. 997-1002.
    Manterfield, D., British Steelmaker, Vol. 10, 1944, pp. 185-192.
15. Jenkins and Gayler., Proceedings of Royal Society, Vol. 129A, 1930, pp. 91-114.
    Joseph, T. L., See reference 11 above.
16. Sordahl, L. O. and Sosman, R. B., Instruments, Vol. 13, 1940, pp. 127-130.
    *Temperature, Its Measurement and Control in Science and Industry*, A. I. P. 1941, pp. 927-936.
17. Blaurock, F., Archiv f.d. Eisenhuttenwesen, Vol. 8, 1934-5, pp. 517-532.
18. Cook, Earnshaw, Transaction American Society for Metals, Vol. 24, 1936, pp. 649-78.
19. Russell, H. W., Lucks, C. F. and Turnbull, L. G., Journal Optical Society of America, Vol. 30, 1940, pp. 248-250.
20. Malpica, J. T. M., General Electric Review, Vol. 44, 1941, pp. 439-443.
21. Virasoro, E. and Berraz, G., Revista Electrotecnica (Buenos Aires) Vol. 31, 1945, pp. 56-60; Engineers' Digest, Vol. 2, 1945, pp. 327-330.
22. Naeser, G., Archiv f.d. Eisenhuttenwesen, Vol. 9, 1936, pp. 483-485.
23. Guthmann, K., Stahl und Eisen, Vol. 56, 1936, pp. 481-489; Stahl und Eisen, Vol. 57, 1936, pp. 1245-1248, 1269-1279.
    Naeser, G., Stahl und Eisen, Vol. 59, 1939, pp. 592-598.
24. Larsen, B. M. and Shenk, W. E., Journal of Applied Physics, Vol. 11, 1940, pp. 555-560.
    Fogle, M. E., Transactions American Electrochemical Society, Vol. 83, 1943, pp. 77-84.
    Land, T., Journal of Iron and Steel Institute, Advance paper No. 6, 1943.
    Land, T., Engineer's Digest, Vol. 2, 1945, p. 21.
    Sosman, R. B., See reference 1 above, pp. 63-69.
25. Koch, R. H. and Schuh, A. E., Transactions American Foundrymen's Association, Vol. 50, 1942, pp. 1163-1184.
26. Bradley, M. J., Twenty-Second Open-Hearth Proceedings, A. I. M. E., 1939, pp. 192-198.
27. Martin, E. D., Twenty-Second Open-Hearth Proceedings, A. I. M. E., 1939, pp. 199-201.
28. *Temperature of Steel Bath Measured in Five Seconds*, Blast Furnace and Steel Plant, Vol. 33, 1945, pp. 712-713.
29. *Basic Open-Hearth Steelmaking*, A. I. M. E. 1944, p. 196.


# DISCUSSION

**PRESENTED BY**


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**E. C. HITE, Combustion and Refractories Engineer, The Timken Roller Bearing Company, Steel and Tube Division, Canton, Ohio**

H. T. CLARK, Research and Development Division, Jones and Laughlin Steel Corporation, Pittsburgh, Pennsylvania

D. G. HARRIS, Metallurgical Research Department, Republic Steel Corporation, Massillon, Ohio

**L. O. Sordahl:** We use the self-generative or solid type of photocell in conjunction with the Collins-Oseland tube method, and the curve relating temperature to current from the cell is now based on a computed scale derived from a comparison of the spectral response curve of the photocell with the black-body curve for any given temperature. The computed temperature curve has been presented in a paper by M. E. Fogle, published in the Trans-Electrochemical Society, 1943, pp. 77-86. The slight difference between the earlier experimental curve and the present computed curve may be attributed to the selection and adoption of a photocell with a slightly different spectral response. Present-day cells are carefully selected within narrow limits and are therefore reproducible.

It is regrettable that so many of the earlier investigators with various types of thermocouples in England and Germany used millivoltmeters for measuring the thermocouple emf. The inferiority of the millivoltmeter is very well emphasized by the improvement in the results of the British Iron and Steel Institute investigations when potentiometers were adopted with the "quick-immersion" thermocouple. Furthermore, as Dr. Clark points out in his report, the couples deteriorate very rapidly at the high temperatures measured and it is therefore essential that all precautions should be taken to minimize the effect of this on the results.

**M. J. Bradley:** Dr. Clark mentioned that temperature variations within the open hearth bath may be large enough to affect the steel, but at the same time may be too small for measurement with the precision of ordinary shop measuring equipment. This condition should be emphasized, as it has been one of the principal obstacles to be overcome in the development and use of a satisfactory bath pyrometer. For example, it has been found that a variation of 10 to 20 degrees F, (about 0.5 per cent of the total temperature), may have an affect on the subsequent processing of steel. In the case of a platinum thermocouple an error of 0.5 per cent may possibly result during one immersion, due to the high temperatures encountered (approximately 3000 F) and the possible contact of the thermocouple with reducing gases during the immersion. Similarly, with a radiation receiver, any change in the optical system, such as may be caused by dirt or film deposits on the lens surface, may cause errors of uncertain magnitude.

To maintain the accuracy necessary for these temperature measurements requires that the method of measurement be accompanied by an adequate method of standardization of the measuring device so that repeated readings will have the same accuracy.

In the case of the platinum thermocouple, its accuracy should be checked with a thermocouple of known accuracy whenever it is to be used more than once, and of course it can be checked with a standard platinum couple very readily. Similarly, in the case of a radiation receiver, the output of the entire instrument as immersed in the metal should be checked and standardized by a comparison with a known and stable standard.

This is one way that the high precision required can be established and maintained under the rugged conditions encountered in the open hearth shop.

**John R. Green:** The comparative operating advantages and limitations of available methods of steel bath temperature measurement have been fairly stated. The bibliography attached to the paper, which covers most of the principal literature on this subject, should be of value to those interested in further research on the problem.

Although bath temperature measurement has been the subject of considerable discussion and research work for a long time, the progress made in the last few years indicates that two basic methods of securing such a measurement, namely the platinum thermocouple and air purged sighting tube designs, have been perfected in rugged mechanical designs to the point where they are practical tools for production use on the open hearth floor and electric furnace shop.

No small part of this accomplishment has been the development and adaption to the problem of an indicating and recording instrument for use with the temperature detecting elements which has the speed, stability, ruggedness and freedom from vibration necessary to take full advantage of improvements in the design of various detecting elements. Such an electronic form of measuring instrument, since it is capable of rapid, stable measurement from electrical impulse of extremely small magnitude, serves to open up the possibilities of: thermocouple elements which develop small millivoltages, the greater stability of calibration from photoelectric cells, or measurement by means of the other physical properties as suggested by Dr. Clark.

Both the silica protected platinum thermocouple and the air purged sighting tube with photronic cell designs have been used successfully in routine production operations for the past two years. A comparison of the operating advantages of these two systems, based on this experience, can be summarized as follows:

1. The platinum thermocouple design is easier to use on the floor, by eliminating air hose connections and associated regulators, etc.
2. The platinum thermocouple method also provides an inherent accuracy of measurement, since standardized elements are used and readings are not influenced by alignment of sighting tube, size of opening, or emissivity of metal.
3. The air purged sighting tube method requires less routine maintenance by the pyrometer department or laboratory, represents a smaller initial investment and somewhat lower cost per reading.

There is every indication that both metallurgical and operating departments will continue to make more extensive use of these tools in securing higher quality and uniformity in steel production.

**E. C. Hite:** I would like to ask Dr. Clark if in using the air purge method he has found that the Bessemer action that you might expect from blowing air through carbon steels affects the readings, particularly with the higher carbon steels?

(*Please turn to page 80*)

# British Steel -

# TODAY AND TOMORROW

***. . . . as a result of constant invention and research, the British steel industry has survived the vicissitudes of war to give ample proof that it will be a potent factor in world reconstruction . . . .***

*by Eric N. Simons*

LONDON, ENGLAND

▲ WORLD WAR II has exercised a profound effect on British steel. Psychologically, in driving out the tendency to rely on established practice, and practically, in putting a premium on the development of new methods and materials, it has been beneficial in equipping the industry for postwar export and home trade. The enormous material damage expected at the outbreak of war never came, and in consequence, records and plant remain, and skill is unimpaired.

A survey, necessarily brief, of the most important developments in Britain likely to react favorably on postwar production will best convey what has been and is being done. One development is the reclaiming at all stages of manufacture of as high a proportion as possible of alloy steel scrap. Turnings are being broken down into chips in machines. Premelting is favored as a means of using mixed alloy steel turnings. Briquetting and baling are being employed, and in the shops careful segregation of different kinds of scrap is being adopted. Magnetic and spark tests are being used in addition to chemical analysis for this purpose.

A remarkable advance is the British invention of a quick-immersion thermocouple, to measure the temperature of molten steel, which is expected to enable a much greater degree of control of steel melting practice to be achieved. It is a 13 per cent rhodium-platinum, platinum thermocouple, 0.5 mm in diameter, lightly sheathed in vitreous silica. That part of the pyrometer immersed in the steel may be protected by diatomite brick or by electrode graphite. The pyrometer is simple to use and gives a written record of the temperature measured.

The capacity of ladles for holding molten steel has been increased by as much as 15 tons in a large ladle. This result has been obtained by careful reduction of the thickness of their linings in those places where least wear takes place. Tilting open hearth furnaces up to 200 tons have been introduced, together with automatic gas and air reversing valves, and other technical devices. In electric furnace melting, the tendency is to increase the melting voltages so as to obtain a faster melting rate and a lower current consumption per ton of steel.

The S.P.B. (Sheffield Process Basic) is another most important new process. It is a basic open hearth process using charges so low in sulphur and phosphorus that they could be used in acid furnaces. The charge contains all the elements required to give, when melted, the analysis called for in the specification, plus the usual margin of carbon. Nickel-chromium-molybdenum steels can be made by this process, and high yields of the valuable alloying elements are obtainable from scrap charges. A comparison with the electric arc furnace can be drawn.

Among the problems that have been successfully overcome are the transportation and use for far greater quantities of low grade indigenous ores; the conservation of alloying elements; the reduction in the number of steel specifications, and the development of new ones to take advantage of the alloying elements in scrap; the black-out difficulties; the planning of factories for the mass production of steel castings; the organization of steel supplies and price stabilization. The experience thereby gained will be of great value in enabling the

industry to meet postwar demands on an economic basis, so that British exports will be able to compete in world markets.

A slag control method has been enlarged to embody also the charging of lime in furnaces using high percentages of molten phosphoric iron. Some increased production will result from the application of this method, but the great point is that closer control of the slag will be one more step toward attaining uniformity of operation and product in the basic open hearth furnace, meaning ever better and more economical steel production.

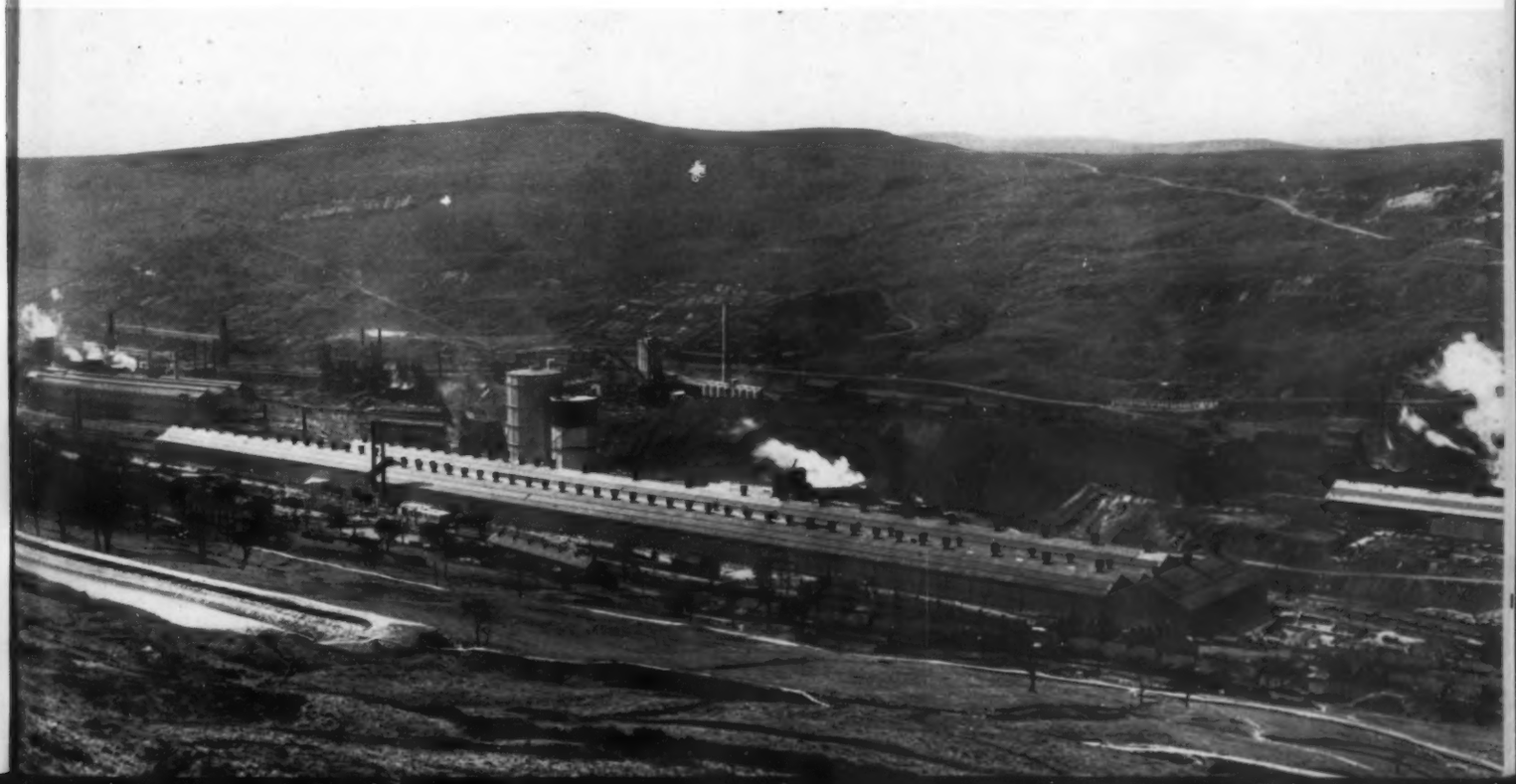
Serious inroads are being made into the world reserves of ores. The ultimate fate of metals and their recovery as scrap are therefore of vital importance to Britain. At present iron and steel represent about 93 per cent of the total world tonnage of metal production. About 15 to 20 per cent of this is lost through rust, and in all, 35 per cent is irrecoverably lost through rust, dispersal and the use of iron and steel in articles from which its recovery is uneconomical. Thus, 65 per cent is left to find its way back into use, of which 25 per cent is process scrap that never leaves the steel works. Britain is aiming to achieve maximum scrap recovery, and in addition to the methods already outlined, she is salvaging all new and as much old scrap as possible; adopting improved methods of segregating scrap of different kinds; sorting, cleaning, and identifying old materials; putting scrap into more suitable form for remelting; avoiding the corrosion of scrap during long storage periods; avoiding the unnecessary use of alloys, which complicate scrap recovery; and reusing old scrap by fabrication and welding. Many of these expedients have been forced upon the steel industry of Britain by the war and the need of economy in metal consumption and ore importation.

Still closer intercompany cooperation is regarded as one of the most promising solutions of a number of problems confronting both individual organizations and different parts of the British steel industry regarded as separate units. In this way, it is designed to undertake pilot plant development before running risks with the production organizations. A huge field of work is to be undertaken, designed to improve metallurgical and engineering technique so that the overall cost of the operations will be reduced. During the war all British steel plants have been running at maximum capacity, with little time available for even ordinary maintenance. Existing plants are therefore to be thoroughly examined with a view to rehabilitation and modernization. As the days of cheap fuel have passed, continuous research is planned into the design of all types of furnaces to reduce fuel consumption and to secure a steady increase in the use of waste heat for steam generation. The close cooperation of management and labor is regarded as essential to a flourishing industry, and suggestions for the achievement of this are already being considered.

A suggestion put forward by one expert is that electric iron reduction furnaces will take the place of blast furnaces. The iron is to be refined in 50-ton electric finishing furnaces, 50 tons of steel being tapped every 45 minutes. Coke is to be made on the steel works site, so that the gas may be utilized for the mixer and soaking pits, or will be made at the coal mines and piped over much longer distances than at present. This development would necessitate contemporaneous development of electric power generating methods and their application, but research is proceeding along these lines.

Much valuable progress has been made in the manufacture of armor-plate steels, which are being manufactured with lower contents of alloying elements without any decline in performance. Hardenability has been rigidly examined with the ultimate object of obtaining satisfactory ballistic properties with lower alloyed steels.

**This general view shows the Richard Thomas and Company plant at Ebbw Vale, where there have been iron and steel works for over 150 years. The first wide strip mill in the United Kingdom is located in this plant.**



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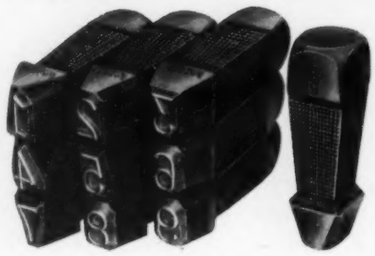

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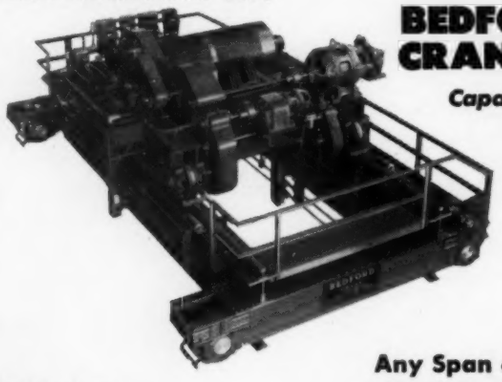

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In every works it has been necessary to expand production capacity, and new plants have been designed on the latest and most modern principles, with a view to reducing movement and consequent transportation costs, obtaining a purer product and thus minimizing waste and increasing efficiency, introducing new processes, and developing new materials. Among the latter may be mentioned a new alloy for loudspeaker permanent magnets, miners' safety lamps, automobile magnetos, electric clocks and meters, phonograph pick-ups and so forth. This, where it is applicable, gives a greater efficiency than any previously known magnet alloy.

A process of exclusively British invention is the atomic hydrogen welding of worn and damaged cutting tools of various kinds, so that they can be repaired or rebuilt with full control of their cutting hardness — a control never previously achieved in the many attempts to adapt this form of welding to cutting tools. This process alone will, it is believed, enable thousands of previously scrapped tools to be reclaimed and given a life that in certain instances can be indefinitely prolonged by repeated rebuilding. Such extensive reclamation will immediately react on the export of British goods, since the cost of cutting tools and the steel of which they are made is an appreciable factor in the machined cost of finished parts.

Another field in which British enterprise will be active is in substituting alloy steels for mild steels in construction work, thereby saving weight, since the same strength is then obtainable from lighter sections. This will involve much redesigning because of the difference in elastic properties.

After World War I, the return of warship armor to industry caused a greater employment of nickel-chromium-molybdenum steels for engineering applications, and it is probable that a more extensive development on the same lines will be seen. Quality is likely to be as important a factor as low price in finding export markets for steel, since engineers are increasingly aware of the advantages of using materials in the most efficient way. Dead weight is minimized by using steels of higher tensile strength, so long as other properties are not sacrificed. Each advance in creep resistance and fatigue resistance enables power plant design to be improved.

The recent action of one British steel firm in appointing its technical heads as special directors is a pointer to the growing importance attached in Britain to the technical as well as commercial control of the steel industry. Well-equipped research laboratories, originally confined to a few works making armaments, are becoming more general. Cooperative research is already on a new footing under the British Iron and Steel Industrial Research Association and much valuable work has already been accomplished.

It will be appreciated, therefore, that the British steel industry emerges from the greatest war in its history not the enfeebled, backward, half-demolished and wholly ruined industry that enemy propaganda sought to suggest. On the contrary, it can be said that British steel, throughout all vicissitudes, has retained its time-honored characteristics, and will be found tomorrow as high in quality, as efficiently manufactured, and as potent a factor in world reconstruction as it has ever been.

# SOME CHARACTERISTICS OF *Blast Furnace Gas*

*. . . . . presenting extensive data on the composition and quantity of blast furnace gas under various conditions . . . . Mr. Rice also brings out several refinements in blast furnace gas analysis which, although often not taken into account, have a material effect upon the accuracy of calculations . . . .*

*by Owen R. Rice*

FREYN ENGINEERING COMPANY
CHICAGO, ILLINOIS

▲ THE substance of this paper consists of basic figures and relations used by the writer in making computations having to do with the production, condition, conduction and combustion of gas that comes from the coke-fired, pig-iron-producing blast furnace. The paper consists primarily of charts and tables, cemented together with a certain amount of explanatory text.

## FUNDAMENTAL RELATIONSHIPS

The gas issuing from the top of an iron blast furnace can be regarded as composed conventionally of:

39 per cent CO plus $CO_2$
2.5 per cent $H_2$
0.1 per cent $CH_4$
58.4 per cent $N_2$

The percentage of hydrogen is influenced by the amount of water which may enter the blast furnace at or near the tuyere level, where temperatures are high enough to dissociate water into $H_2$ and $O_2$. Such water can and does come from moisture in the blast, or from leaking cooling devices. The latter source has perhaps the more pronounced influence upon the amount of $H_2$ in the top gas because such water enters and dissociates at the periphery of the furnace, and the hydrogen may sneak furtively up the walls without doing much ore reducing although it is admirably adapted thereto. Moisture in the blast, on the other hand, penetrates toward the interior of the furnace, and its dissociation products ascend through the stock in a normal manner; the hydrogen taking on oxygen from the ore and returning to the form of $H_2O$; the oxygen going immediately to CO in the presence of hot coke. At all events, we have detected as high as 5.4 per cent hydrogen in blast furnace gas immediately subsequent to the severe burning of several tuyeres, while the gas engine blowers and power units, unaccustomed to so rich a diet, fired before the end of compression stroke and blew their packing merrily. We have otherwise found nothing quite attaining such a hydrogen figure even at times of exceedingly high atmospheric humidity, nor apparently do those who report on the adding of water to the blast.

John J. Alexander ("Blast Furnace Moisture Control." Blast Furnace and Steel Plant, October 1944) speaks of adding as much as 7 grains per cu ft to the natural water content of blast. He says that 4 added grains increase the hydrogen in the top gas by 0.5 per cent. Thus, he would seem to get about 3.5 per cent $H_2$. At another plant the writer was told that the normal gas contained 2 per cent $H_2$. When 8 grains of moisture were added to the blast, the hydrogen in the gas went to 3 per cent. This would exactly check Alexander.

Methane ($CH_4$) is probably a resultant of volatile matter in the coke, which source might also contribute

Presented before the Chicago Session of A. I. S. E. Annual Meeting, October 1, 1945.

illuminants such as ethylene ($C_2H_4$). This latter sometimes does show up, but in very small percentage. Methane might theoretically form from hydrogen in contact with hot coke, but the writer has never found any relation between $H_2$ and $CH_4$ in blast furnace gas such as would point to the actuality of such a reaction or such an origin.

The percentage of nitrogen in blast furnace gas is generally assumed as fairly constant at about 58.4 per cent. Since the air blast is the source of almost all of the nitrogen in the gas, and since air contains 79.1 per cent $N_2$ by volume, the figure 79.1÷58.4 or 1.354 cu ft of gas per cu ft of blast, is a highly convenient one for designating the volumetric ratio between blast blown and gas produced. The writer uses this figure, though perfectly cognizant that it is based on an assumption not necessarily true. For one thing, a furnace operated on a burden unusually low in limestone (or other carbonate-bearing material) will probably produce a gas unusually high in $N_2$. Gas analyses made by the writer immediately after a blow-in, when the limestone proportion in the charge was being built up from practically zero toward normal, showed these progressively decreasing nitrogen contents:

| Hr after wind on | Per cent $N_2$ in gas | Per cent CO plus $CO_2$ in gas |
|---|---|---|
| 4 | 64.52 | 33.30 |
| 5 | 63.90 | 33.50 |
| 6 | 62.69 | 35.70 |
| 7¾ | 61.77 | 36.50 |
| 13 | 60.73 | 37.25 |
| 24 | 60.00 | 38.10 |
| 46 | 58.59 | 39.70 |

The $CO_2$ evolved from the stone or from other carbonates, whether or not it reaches the furnace top in that form, acts as a diluent which affects the $N_2$ percentage considerably.

Then again, the introduction, in any manner, of blast oxygen that has no nitrogen accompaniment will obviously cause a lowered percentage of $N_2$ in the gas. Thus a wet-blast furnace with a certain amount of oxygen being introduced in the form of $H_2O$, should yield a lower nitrogen gas than a dry-blast furnace.

Nevertheless, a study of many hundreds of blast furnace gas analyses leads to the comfortable and useful, though perhaps not meticulously accurate, conclusion that the nitrogen is fairly constant at about 58.4 per cent. It follows that, except for the fluctuations in hydrogen and methane, which at most are of small numerical degree, the sum of CO and $CO_2$ is fairly constant at about 39 per cent. As a corollary, 1.354 cu ft of gas can be expected to issue from the furnace top for each cu ft of blast entering at the bottom.

Another useful relationship is that between the amount of coke charged to the furnace and the amount of gas produced; in short, the cu ft of gas per lb of coke. The fundamental blast furnace reaction: $O_2+2C=2CO$, leads to the basic figure of 75.2 cu ft of dry air (at 60 F and 30 in. Hg) per lb of carbon burned at the tuyeres. If there are 1.354 cu ft of gas from each cu ft of air, then 75.2 x 1.354 or about 102 cu ft of gas (at 60 F and 30 in. Hg) are evolved per lb of carbon burned at the tuyeres.

Coke is not 100 per cent carbon by any means, nor does all that is charged succeed in getting burned at the tuyeres. Consequently, we have set up Table I showing the gas production per lb of coke charged at various percentages of carbon in coke and at various percentages of coke burned at the tuyeres, over ranges familiar to blast furnace practice.

**TABLE I**

**CU FT OF GAS (60 F, 30 IN. HG) PRODUCED PER LB OF COKE CHARGED**

| Per cent of carbon (or coke) charged burned at tuyeres | Per cent fixed carbon in the coke | | | |
|---|---|---|---|---|
| | 84 | 86 | 88 | 90 |
| 78 | 66.8* | 68.3 | 69.9 | 71.5 |
| 79 | 67.6 | 69.3 | 70.8 | 72.4 |
| 80 | 68.4 | 70.1 | 71.7 | 73.3 |
| 81 | 69.2 | 70.8 | 72.4 | 74.1 |
| 82 | 69.5 | 72.0 | 73.6 | 75.2 |

*Sample computation: 78 per cent of 84 per cent fixed carbon coke equals 0.655 lb carbon at tuyeres per lb coke charged.
0.655 x 102 equals 66.8 cu ft gas per lb coke charged.

## GRADES OF BLAST FURNACE GAS

The richness of the natural gases, coke oven gas and the like is apt to make one view with a disdainful smile the modest 90 Btu of latent heat in each cu ft of blast furnace gas. Yet its useful toil is nothing to laugh at, for in the gas output of a thousand ton blast furnace there is the potentiality of some 15,000 hp.

It is customary to grade blast furnace gas according to its thermal value which rarely, in pig iron manufacture, exceeds 100 Btu (gross) per cu ft, and as rarely falls below 80. However, this 20 per cent span is quite important to the consumer, particularly in its lower reaches, where the gas approaches a point of difficult ignition.

Ninety per cent of the thermal value of blast furnace gas resides in the carbon monoxide content. This brings us back to our previous mention of the uniformity of CO plus $CO_2$ at about 39 per cent. Within this substantially constant figure, the ratio of CO to $CO_2$ varies considerably. It varies according to the coke rate of the blast furnace. As the pounds of coke per ton of pig go down, the CO:$CO_2$ ratio goes down; more significant, the CO percentage goes down, and the thermal value goes down. This factor may be of more specific interest to the blast furnace man than to the user of the gas, but it will do the latter no harm to be aware of the reason for variations that may occur in the thermal value of the fuel that he purchases, particularly as his gloomiest days are apt to be those upon which the sun shines brightest for the blast furnace operator who is on an agreeable coke-rate bonus.

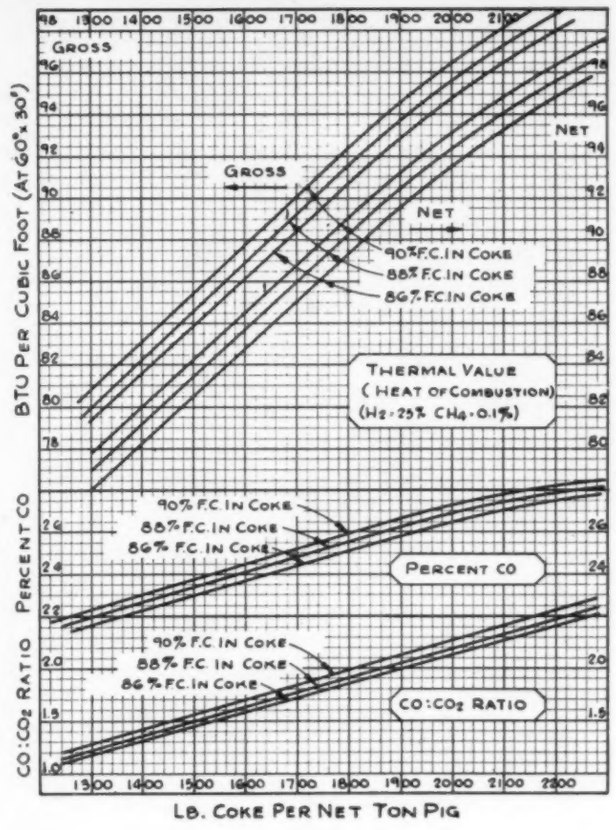



**Figure 1 — Relation of blast furnace gas quality to coke rate.**

Figure 1 shows, among other things, the probable relation between the blast furnace coke rate (in lb per net ton of pig), and the $CO:CO_2$ ratio of the gas. Derived from this ratio is the CO percentage, and finally the gross and net thermal value, wherein the hydrogen (at 2.5 per cent) and the methane (at 0.1 per cent) participate. The basis of the $CO:CO_2$ graph in Figure 1 is a considerable mass of operating data, much of it published through the years over the names of such blast furnace authorities as Dr. Walther Mathesius, F. M. Rich, T. L. Joseph, S. P. Kinney, and others, and a similarly substantial mass of data accumulated by the writer.

The curves seem to be exponential in character. They probably attain a horizontal direction at an infinite coke rate per ton pig, where the blast furnace would be nothing more than a slagging gas producer. The gas would seemingly reach an ultimate thermal value in the general vicinity of 130 Btu per cu ft.

Referring again for a moment to the CO to coke rate curve on Figure 1, it will be noted that 1 per cent change in CO content of the gas corresponds to about a 160 lb change in coke rate. This does not at all agree with Dr. Hugo Bansen, who has propounded a relation of 1 per cent CO to about 40 lb of coke. It does not seem possible to reconcile Bansen with the actual facts of blast furnace practice. On his basis, a change in coke rate from 1400 lb per ton of pig to 1800 lb per ton of pig would raise the CO in the gas from about 23 per cent to 33 per cent. He would have us expect a gas with a thermal value of 115 Btu at a coke rate which is typical of current blast furnace practice. This does not even remotely approach actual findings.

## TYPICAL BLAST FURNACE GAS

Blast furnace gas has deteriorated over the years. In 1913 it probably had a prevailing gross thermal value of about 99 Btu per cu ft. In the ensuing decade it lost about 2 heat units. Ten years later, in 1933, the average blast furnace gas in this country probably hit an all-time low of about 89 Btu per cu ft.

This account is based on the premise that the $CO:CO_2$ ratio varies with the coke rate, and that consequently the CO content and hence the Btu value do likewise. In Table II are the average annual coke rates in lb per net ton of pig iron (not including ferro alloys) throughout the country. In an adjoining column are the corresponding probable average thermal values of blast furnace gas, as derived from Figure 1.

**TABLE II**

**ANNUAL COKE RATES AND GAS THERMAL VALUES**

| Year | Lb of coke per net ton of pig iron (Not incl. ferro alloys) | Approx. gross Btu value of blast furnace gas (Based on 88 per cent fixed carbon coke) |
|---|---|---|
| 1913 | 2173 | 98.5 |
| 1918 | 2121 | 97.6 |
| 1923 | 2090 | 97.2 |
| 1929 | 1822 | 92.0 |
| 1930 | 1805 | 91.8 |
| 1931 | 1765 | 90.8 |
| 1932 | 1760 | 90.5 |
| 1933 | 1727 | 89.3 |
| 1934 | 1775 | 91.0 |
| 1935 | 1740 | 90.1 |
| 1936 | 1790 | 91.4 |
| 1937 | 1807 | 91.8 |
| 1938 | 1775 | 90.9 |
| 1939 | 1760 | 90.7 |
| 1940 | 1757 | 90.7 |
| 1941 | 1745 | 90.2 |
| 1942 | 1791 | 91.4 |
| 1943 | 1801 | 91.5 |
| 1944 | 1810 | 92.0 |

**The figures in the middle column come from "Minerals Yearbook," 1935, 1936, 1941, 1943, and from "Mineral Market Report," MMS 1331, July 13, 1945. The figures for 1929, 1930, 1931, and 1932 were computed to eliminate ferro alloys. From 1935 on, 1778 is an average figure.**

The values in Table II are shown graphically in Figure 2.

It is interesting to note how the low coke rates (and the low gas thermal values) seem to attend the depression years. Doubtless only the best furnaces were in run, on optimum raw materials, at economical ratings, with maximum supervision, and with highest workmanship. With the increasing tempo after 1941, every furnace was in blast (lining or no lining), new ones were having birth pains, raw materials were anything red or black, blast rates were what the engines could do without falling apart, supervision was spread thin, and

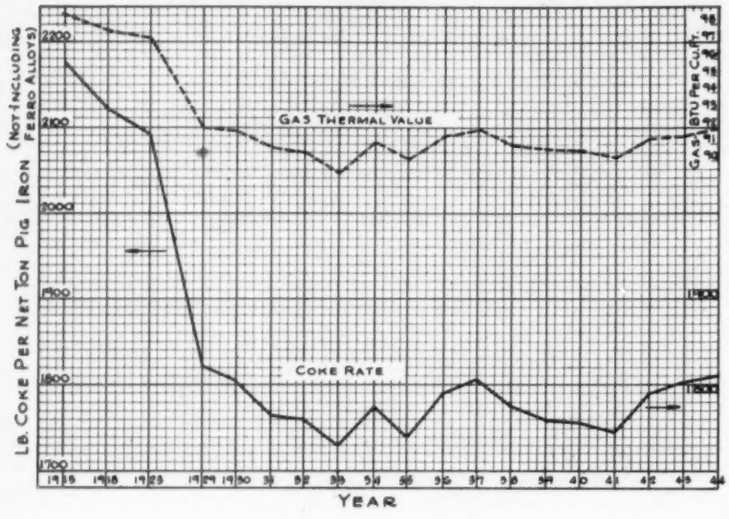



**Figure 2 — Annual average coke rate for pig iron furnaces in the U. S. A.**

labor was handling machine guns rather than mud-guns. Economy took second place to tonnage, and by 1944, coke rates and gas heat values were the highest since 1929.

What, now, shall we denote as "typical" blast furnace gas? The average for the past 30 odd years is probably about 95 Btu, yet we would hardly permit the practice of the past to participate in designating prevailing conditions. Nor would a flat average for the last 10 years seem any more satisfactory, for a figure of about 91 Btu would leave quite uninterested many furnace operators and furnace gas users who have to deal with considerably leaner or considerably richer gas.

The writer has had the opportunity to assemble a large mass of individual blast furnace operating data covering the last six or eight years. It includes the coke rates at 80 typical blast furnaces and represents over 140 operating months, almost 12 furnace years. Classifying these data on the basis of coke rates (and gas thermal value as determined from Table I) we have the results given in Table III.

**TABLE III**

**COKE RATES AND GAS THERMAL VALUES AT TYPICAL BLAST FURNACES**

| Furnace years represented | Lb coke per net ton of pig | | Gross Btu per cu ft of gas | |
|---|---|---|---|---|
| | Range | Average | | |
| 2 | Below 1600 | 1520 | 85.2 | |
| 3 | 1600-1700 | 1680 | 88.9 | 87 lean |
| 3 | 1700-1800 | 1750 | 90.4 | |
| 2 | 1800-1900 | 1840 | 92.5 | 92 medium |
| 1 | 1900-2000 | 1943 | 94.6 | |
| 1 | Above 2000 | 2133 | 97.7 | 98 rich |
| 12 | | 1757 | | |

Consideration of the data in Table III leads us to set down in the right-hand column, three grades of gas which seem to represent typical current American blast furnace practice. Accordingly, a scrutiny of the properties of these three grades of gas should prove useful to almost anyone having to do with blast furnace gas.

The theoretical analyses of these three typical grades of blast furnace gas are substantially as set forth in Table IV.

**TABLE IV**

**THEORETICAL ANALYSES OF TYPICAL BLAST FURNACE GASES**

| | Lean | Medium | Rich |
|---|---|---|---|
| $CO_2$ per cent | 14.9 | 13.3 | 11.5 |
| CO per cent | 24.1 | 25.7 | 27.5 |
| $H_2$ per cent | 2.5 | 2.5 | 2.5 |
| $CH_4$ per cent | 0.1 | 0.1 | 0.1 |
| $N_2$ per cent | 58.4 | 58.4 | 58.4 |
| | 100.0 | 100.0 | 100.0 |
| **Thermal value or heat of combustion Btu per cu ft (at 60 F and 30 in.)** | | | |
| Gross | 86.8 | 92.0 | 97.7 |
| Net | 85.5 | 90.7 | 96.4 |

**Thermal values are based on 323 Btu per cu ft for CO; 324.5 for gross $H_2$; 274.5 for net $H_2$; and 1012 for gross $CH_4$; 912 for net $CH_4$. Various authorities show 321.7 to 323.5 for CO, 323 to 326.2 for $H_2$ gross, and 1009 to 1014.7 for $CH_4$ gross.**

## ACTUAL BLAST FURNACE GAS

In our dealings with blast furnace gas, some of us will have to admit to making complacent assumptions. We take an Orsat apparatus and we get some burette readings; the slide rule smokes a little, and out we come with 87 per cent efficiency, and we go to lunch well satisfied.

Actually we made many assumptions in the process. We assumed that the gas sample represented the gas in the main, and we assumed that the Orsat readings gave us a report on theoretical dry gas. These assumptions probably were just a little wrong. One of the purposes of this discussion is to show that while in some cases these assumptions may be of little consequence, in other cases they may be worth attending to.

To all practical purposes, the gases shown in Table IV have never existed. The nearest approach may have been in zero weather, at the end of a long, unlined main. As the gases listed in Table IV came from the top of the blast furnace, or as they existed in the mains after a wet-washing plant in Alabama in August, or as they went through an Orsat apparatus on a very hot day, they had actual analyses as indicated in Table V.

**TABLE V**

**ACTUAL ANALYSES OF TYPICAL BLAST FURNACE GASES CONTAINING 30 GRAINS $H_2O$ PER CU FT DRY GAS**

| Per cent | Lean | Medium | Rich |
|---|---|---|---|
| $CO_2$ | 13.67 | 12.22 | 10.57 |
| CO | 22.13 | 23.60 | 25.25 |
| $H_2$ | 2.29 | 2.29 | 2.29 |
| $CH_4$ | .09 | .09 | .09 |
| $N_2$ | 53.55 | 53.55 | 53.55 |
| $H_2O$ | 8.25 | 8.25 | 8.25 |
| **Heat of combustion, Btu per standard cu ft of actual gas** | | | |
| Gross | 79.8 | 84.0 | 89.8 |
| Net | 78.6 | 83.3 | 88.6 |

There is nothing particularly mysterious about all this. We have simply added the water vapor that can accompany the gas under the conditions named. The point is that we frequently may not take the water vapor into consideration. We assume it isn't there. But gas mains have to convey it, flow meters record it, cleaning equipment and burners have to pass it, analysis apparatus overlooks it, and perhaps most important of all, combustion is affected by it.

## CORRECTIONS IN ANALYSIS

The volumetric analysis of blast furnace gas is not always what it seems. Being a wet analysis, through and over reagents in aqueous solutions, burrette readings are those of a moisture saturated gas. If the Orsat apparatus had acquired a temperature of 110 F, it could ascribe to a sample of blast furnace gas a thermal value 8 Btu less than it should be on a dry basis. Perhaps some of the mystifying reports of 75 Btu blast furnace gas can be attributed to a chemist simmering in an over-heated laboratory, with the Orsat apparatus in a sunny window.

In Table VI are the correction factors that should be applied for various temperature of the gas analysis apparatus.

**TABLE VI**

**CORRECTION FACTORS MULTIPLY BURETTE READINGS BY THESE FIGURES TO GET DRY GAS ANALYSIS**

| Temperature of apparatus F | 30-in. barometer | 26.5-in. barometer |
|---|---|---|
| 50 | 1.01 | 1.015 |
| 70 | 1.025 | 1.03 |
| 90 | 1.05 | 1.06 |
| 100 | 1.07 | 1.08 |
| 110 | 1.10 | 1.11 |

It will be noted that the effect of low barometer in increasing the weight of a cu ft of aqueous vapor is of such small proportions that it can usually be discounted.

The writer is aware that the aqueous tensions of solutions are less than that of pure water. However, in the concentration of reagents employed in gas analysis, the modification is a small one. For example, the caustic potash solution used for $CO_2$ absorption consists typically of 316 grams of KOH to 1000 cu cm of water, or about 10 gram moles of KOH to 100 gram moles of $H_2O$. According to Raoult's Law:

$P$ equals $P_oX_o$

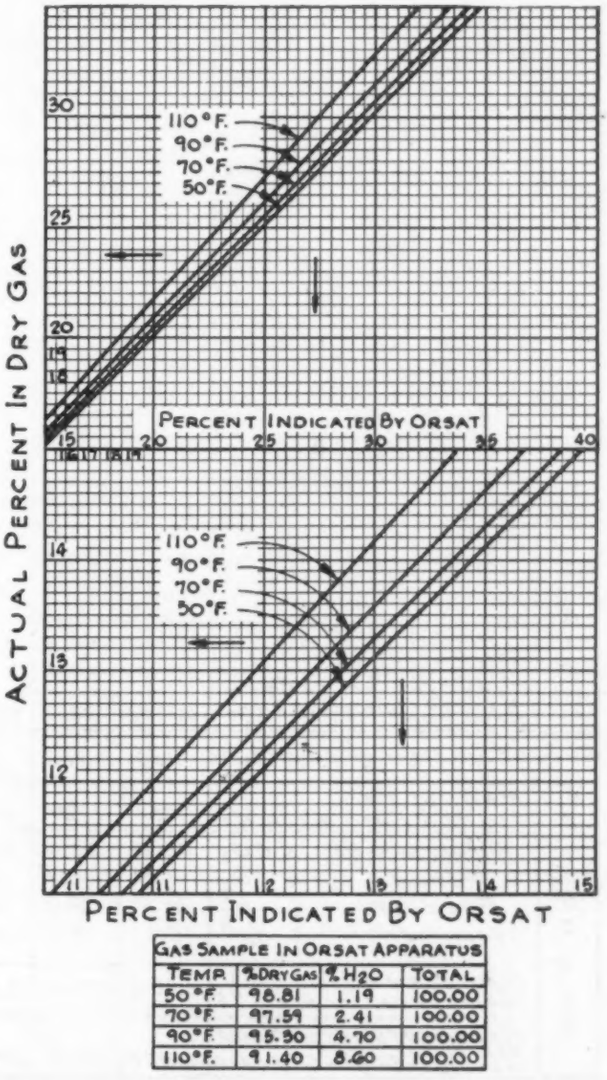
where $P$ equals vapor tension of a solution

$P_o$ equals vapor tension of the solvent (water)

$X_o$ equals mole fraction : $100 \div (100+10) = 0.908$.

Accordingly, the vapor tension of the KOH reagent in the gas analysis apparatus is about 91 per cent (reference tables show 93 per cent) that of pure water. Hence, the correction factors in Table VI are theoretically in error by 7 to 9 per cent of their departure from unity. For instance, the correction for 90 F should be

**Figure 3 — Relation between actual dry gas analysis and Orsat analysis.**



## TABLE VII

### CHARACTERISTICS OP 87 BTU BLAST FURNACE GAS

| "STANDARD" GAS - AS OF 60°F X 30" Hg. "DRY" GAS - NO WATER VAPOR "ACTUAL" GAS - INCLUDES WATER VAPOR AIR ASSUMED HAS 6 GR. $H_2O$/STD. DRY C.F. | | DRY GAS | | | SATURATED GAS | | | | "HOT" GAS WITH 30 GR. $H_2O$ PER C.F. STD. DRY GAS | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 60°F | 200 | 400 | 60°F | 80 | 100 | 110 | 200°F | 300 | 400 |
| GRAINS $H_2O$/C.F. STD. DRY GAS | | 0 | 0 | 0 | 5.84 | 11.77 | 22.70 | 31.3 | 30 | 30 | 30 |
| C.F. $H_2O$/C.F. STD. DRY GAS | | 0 | 0 | 0 | .0175 | .0353 | .0682 | .0940 | .090 | .090 | .090 |
| ANALYSIS OF ACTUAL GAS - VOLUMETRIC - PER CENT | $CO_2$ | 14.9 | 14.9 | 14.9 | 14.67 | 14.40 | 13.96 | 13.62 | 13.69 | 13.69 | 13.69 |
| | CO | 24.1 | 24.1 | 24.1 | 23.70 | 23.27 | 22.56 | 22.00 | 22.13 | 22.13 | 22.13 |
| | $H_2$ | 2.5 | 2.5 | 2.5 | 2.46 | 2.42 | 2.34 | 2.29 | 2.29 | 2.29 | 2.29 |
| | $CH_4$ | .1 | .1 | .1 | .10 | .10 | .09 | .09 | .09 | .09 | .09 |
| | $N_2$ | 58.4 | 58.4 | 58.4 | 57.35 | 56.40 | 54.67 | 53.40 | 53.55 | 53.55 | 53.55 |
| | $H_2O$ | 0 | 0 | 0 | 1.72 | 3.41 | 6.38 | 8.60 | 8.25 | 8.25 | 8.25 |
| % DRY GAS IN MIXTURE | | 100 | 100 | 100 | 98.28 | 96.59 | 93.62 | 91.40 | 91.75 | 91.75 | 91.75 |
| LATENT HEAT BTU/STD. C.F. OF ACTUAL GAS | GROSS | 86.8 | 86.8 | 86.8 | 85.5 | 83.8 | 81.3 | 79.3 | 79.8 | 79.8 | 79.8 |
| | NET | 85.5 | 85.5 | 85.5 | 84.1 | 82.5 | 80.0 | 78.1 | 78.6 | 78.6 | 78.6 |
| SENSIBLE HEAT (ABOVE 60°) BTU/STD. C.F. ACTUAL GAS | | 0 | 2.7 | 6.7 | 0 | .4 | .8 | 1.0 | 2.7 | 4.7 | 6.8 |
| TOTAL HEAT BTU/STD. C.F. ACTUAL GAS | GROSS | 86.8 | 89.5 | 93.5 | 85.5 | 84.2 | 82.1 | 80.3 | 82.5 | 84.5 | 86.6 |
| | NET | 85.5 | 88.2 | 92.2 | 84.1 | 82.9 | 80.8 | 79.1 | 81.3 | 83.3 | 85.4 |
| MEAN HEAT CAPACITY BTU/STD. C.F. ACT'L. GAS/°F ABOVE 60° | | .01928 | .01945 | .01962 | .01931 | .01938 | .01948 | .01958 | .01967 | .01976 | .01985 |
| COMBUSTION C.F. STD. DRY AIR/C.F. STD. ACT. GAS | | .645 | .645 | .645 | .634 | .623 | .603 | .590 | .593 | .593 | .593 |
| THEOR. AIR — PRODUCTS STD. C.F./C.F. STD. ACTUAL GAS | | 1.520 | 1.520 | 1.520 | 1.512 | 1.503 | 1.486 | 1.475 | 1.477 | 1.477 | 1.477 |
| THEOR. AIR — ANALYSIS OF ACTUAL PRODUCTS (VOLUMETRIC) PER CENT | $CO_2$ | 25.7 | 25.7 | 25.7 | 25.4 | 25.1 | 24.6 | 24.2 | 24.3 | 24.3 | 24.3 |
| | $O_2$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | $N_2$ | 72.0 | 72.0 | 72.0 | 71.2 | 70.5 | 68.9 | 67.8 | 68.0 | 68.0 | 68.0 |
| | $H_2O$ | 2.3 | 2.3 | 2.3 | 3.4 | 4.5 | 6.5 | 8.0 | 7.7 | 7.7 | 7.7 |
| THEOR. AIR — FLAME TEMP. (THEOR.) (BASED ON NET TOT. HEAT) °F | | 2505 | 2570 | 2670 | 2480 | 2455 | 2410 | 2385 | 2440 | 2510 | 2545 |
| THEOR. AIR — MEAN HEAT CAP'Y. OF PRODUCTS AT THEOR. FLAME TEMP. BTU/STD. C.F. ACT. PROD. | | .02298 | .02308 | .02320 | .02302 | .02300 | .02300 | .02300 | .02310 | .02320 | .02320 |
| 20% EXCESS AIR — C.F. STD. DRY AIR/C.F. STD. ACT. GAS | | .774 | .774 | .774 | .761 | .748 | .724 | .708 | .711 | .711 | .711 |
| 20% EXCESS AIR — PRODUCTS STD. C.F./C.F. STD. ACTUAL GAS | | 1.651 | 1.651 | 1.651 | 1.640 | 1.629 | 1.608 | 1.594 | 1.597 | 1.597 | 1.597 |
| 20% EXCESS AIR — ANALYSIS OF ACTUAL PRODUCTS (VOLUMETRIC) PER CENT | $CO_2$ | 23.7 | 23.7 | 23.7 | 23.5 | 23.2 | 22.8 | 22.4 | 22.5 | 22.5 | 22.5 |
| | $O_2$ | 1.6 | 1.6 | 1.6 | 1.6 | 1.6 | 1.6 | 1.6 | 1.6 | 1.6 | 1.6 |
| | $N_2$ | 72.5 | 72.5 | 72.5 | 71.7 | 71.0 | 69.5 | 68.5 | 68.7 | 68.7 | 68.7 |
| | $H_2O$ | 2.2 | 2.2 | 2.2 | 3.2 | 4.2 | 6.1 | 7.5 | 7.2 | 7.2 | 7.2 |
| 20% EXCESS AIR — FLAME TEMP. (THEOR.) (BASED ON NET TOT. HEAT) °F | | 2350 | 2415 | 2510 | 2330 | 2310 | 2280 | 2250 | 2295 | 2355 | 2395 |
| 20% EXCESS AIR — MEAN HEAT CAP'Y OF PROD. AT THEOR. FLAME TEMP. BTU/STD. C.F. ACT. PROD. | | .02253 | .02265 | .02270 | .02258 | .02255 | .02260 | .02265 | .02268 | .02270 | .02281 |
| 40% EXCESS AIR — C.F. STD. DRY AIR/C.F. STD. ACT. GAS | | .903 | .903 | .903 | .888 | .872 | .844 | .826 | .830 | .830 | .830 |
| 40% EXCESS AIR — PRODUCTS STD. C.F./C.F. STD. ACTUAL GAS | | 1.781 | 1.781 | 1.781 | 1.771 | 1.755 | 1.730 | 1.714 | 1.717 | 1.717 | 1.717 |
| 40% EXCESS AIR — ANALYSIS OF ACTUAL PRODUCTS (VOLUMETRIC) PER CENT | $CO_2$ | 22.0 | 22.0 | 22.0 | 21.9 | 21.5 | 21.2 | 20.8 | 20.9 | 20.9 | 20.9 |
| | $O_2$ | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 2.9 | 2.9 | 2.9 | 2.9 | 2.9 |
| | $N_2$ | 72.9 | 72.9 | 72.9 | 72.0 | 71.5 | 70.2 | 69.3 | 69.4 | 69.4 | 69.4 |
| | $H_2O$ | 2.1 | 2.1 | 2.1 | 3.1 | 4.0 | 5.7 | 7.0 | 6.8 | 6.8 | 6.8 |
| 40% EXCESS AIR — FLAME TEMP. (THEOR.) (BASED ON NET TOT. HEAT) °F | | 2220 | 2280 | 2370 | 2195 | 2180 | 2160 | 2130 | 2170 | 2230 | 2265 |
| 40% EXCESS AIR — MEAN HEAT CAP'Y. OF PROD. AT THEOR. FLAME TEMP. BTU/STD. C.F. ACT. PROD. | | .02220 | .02231 | .02240 | .02223 | .02221 | .02224 | .02223 | .02232 | .02240 | .02243 |

NOTE: COMBUSTION CRITERIA SHOWN GRAPHICALLY ON FIGS. 4-a AND -b

TABLE VII-a

STACK LOSSES WITH 87 BTU BLAST FURNACE GAS

| | | Stack gas temp F | Dry gas | | | Saturated gas | | | | Hot gas with 30 grains $H_2O$ per cu ft std dry gas | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 60 F | 200 F | 400 F | 60 F | 80 F | 100 F | 110 F | 200 F | 300 F | 400 F |
| Theoretical air | Mean heat capacity of products above 60 F (Btu/cu ft/deg) | 300 | .02031 | .02031 | .02031 | .02032 | .02038 | .02040 | .02044 | .02043 | .02043 | .02043 |
| | | 500 | .02058 | .02058 | .02058 | .02059 | .02064 | .02068 | .02071 | .02071 | .02071 | .02071 |
| | | 700 | .02082 | .02082 | .02082 | .02084 | .02088 | .02090 | .02094 | .02094 | .02094 | .02094 |
| | Per cent stack loss | 300 | 8.7 | 8.4 | 8.0 | 8.8 | 8.9 | 9.0 | 9.2 | 8.9 | 8.7 | 8.5 |
| | | 500 | 16.1 | 14.8 | 14.9 | 16.3 | 16.5 | 16.8 | 17.0 | 16.5 | 16.2 | 15.8 |
| | | 700 | 23.7 | 23.0 | 22.0 | 24.1 | 24.3 | 24.7 | 25.0 | 24.4 | 23.8 | 23.2 |
| 20% Excess air | Mean heat capacity of products above 60 F (Btu/cu ft/deg) | 300 | .02017 | .02017 | .02017 | .02020 | .02022 | .02027 | .02030 | .02029 | .02029 | .02029 |
| | | 500 | .02042 | .02042 | .02042 | .02047 | .02048 | .02052 | .02057 | .02054 | .02054 | .02054 |
| | | 700 | .02066 | .02066 | .02066 | .02070 | .02070 | .02075 | .02078 | .02077 | .02077 | .02077 |
| | Per cent stack loss | 300 | 9.3 | 9.0 | 8.7 | 9.4 | 9.5 | 9.7 | 9.8 | 9.6 | 9.3 | 9.1 |
| | | 500 | 17.4 | 16.9 | 16.1 | 17.5 | 17.7 | 17.9 | 18.2 | 17.7 | 17.3 | 16.9 |
| | | 700 | 25.6 | 24.8 | 23.7 | 25.8 | 26.0 | 26.4 | 26.8 | 26.1 | 25.5 | 24.9 |
| 40% Excess air | Mean heat capacity of products above 60 F (Btu/cu ft/deg) | 300 | .02008 | .02008 | .02008 | .02010 | .02011 | .02014 | .02016 | .02016 | .02016 | .02016 |
| | | 500 | .02034 | .02034 | .02034 | .02036 | .02036 | .02037 | .02042 | .02041 | .02041 | .02041 |
| | | 700 | .02056 | .02056 | .02056 | .02056 | .02059 | .02062 | .02063 | .02063 | .02063 | .02063 |
| | Per cent stack loss | 300 | 10.0 | 9.7 | 9.3 | 10.2 | 10.2 | 10.4 | 10.5 | 10.3 | 10.0 | 9.8 |
| | | 500 | 18.6 | 18.0 | 17.2 | 18.8 | 19.0 | 19.2 | 19.5 | 19.0 | 18.5 | 18.1 |
| | | 700 | 27.4 | 26.6 | 25.4 | 27.7 | 27.9 | 28.3 | 28.6 | 27.9 | 27.2 | 26.6 |

about 1.046 instead of 1.05. This refinement is beyond the sensitivity of the analysis method. Furthermore, the error is not altogether present because the gas sample is returned from the reagent pipettes to the measuring burette where it is once more over water. Hence, the effect of the reagents themselves can be discounted, and the correction values in Table VI stand as shown.

Figure 3 shows the actual corrected readings applicable to a gas analysis. The chart is arranged with two scales in order to afford visibility in the small percentage brackets. The necessary correction is negligible in the one to ten per cent bracket. Above 10 per cent they had well be taken into account. The corrections apply with as much significance to stack gas analyses as to fuel gas analyses.

## COMBUSTION CRITERIA OF BLAST FURNACE GAS

Tables VII and VII-a, VIII and VIII-a, and IX and IX-a show a mass of figures associated with the condition and combustion of the three typical grades of blast furnace gas set forth in Table IV. Each grade is presented in a number of conditions, namely dry, saturated and hot.

The dry condition is really nonexistent to all practical purposes. Still, it is the one that we not infrequently are inclined to make use of — the one with which some of us are most familiar.

The wet condition is probably the most frequently encountered in actual practice. It represents blast furnace gas as it comes from almost any wet-washing process, at 100 per cent humidity. It represents the analysis that would be reported by an Orsat or similar apparatus, except that the $N_2$ and $H_2O$ would be lumped together.

The hot condition represents the gas as it comes from the blast furnace top, or from the dust catcher, whirler or other dry dust separator. We have assigned a moisture content of 30 grains per cu ft which is probably typical of such gas.

We shall not go tediously into a detailed explanation of these tables. A few moments' scrutiny should suffice to make comprehensible their substance, significance and possible usefulness. It may be helpful to point out that the theoretical dry-basis analysis of the gas established in Table IV, that is, the analysis with which the blast furnace man and probably the blast furnace gas user is most familiar, appears in heavy box in the upper left-hand corner of the data.

Attention is drawn to the horizontal line of figures with the caption, Total Heat, Btu per standard cu ft. The venerable controversy between "wet" gas and "hot" gas may find interesting material there. Note, for instance, that 80 F "wet" gas has the same total heat as 300 F "hot" gas (provided the latter has 30 grains water vapor per cu ft). The "hot" gas party scores a happy little victory when they point out the flame temperature figures lower down in the tables. It will be noted that the 300 F "hot" gas has something of an edge on the 80 F "wet" gas by 40 or 50 degrees.

Several of the primarily important combustion criteria of these three grades of blast furnace gas are shown graphically. Volume of combustion products, volume of air, oxygen in the products, theoretical flame temperatures and the percentages of stack losses represented under various conditions of combustion are shown on Figure 4-a, b and c, Figure 5-a, b and c, and Figure 6-a, b and c.

## TABLE VIII

### CHARACTERISTICS OF 92 BTU BLAST FURNACE GAS

| Standard Gas-as of 60°F x 30" Hg. "Dry" Gas-No Water Vapor "Actual" Gas-Includes Water Vapor Air Assumed Has .0124 Lb. $H_2O$/Std. Dry C.F. | | Dry Gas | | | Saturated Gas | | | | "Hot" Gas with 30 Gr. $H_2O$ Per C.F. Std. Dry Gas | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 60°F | 200 | 400 | 60°F | 80 | 100 | 110 | 200°F | 300 | 400 |
| Grains $H_2O$/C.F. Std. Dry Gas | | 0 | 0 | 0 | 5.84 | 11.77 | 22.70 | 31.3 | 30 | 30 | 30 |
| C.F. $H_2O$/C.F. Std. Dry Gas | | 0 | 0 | 0 | .0175 | .0353 | .0682 | .0940 | .090 | .090 | .090 |
| Analysis of Actual Gas -Volumetric- Per Cent | $CO_2$ | 13.3 | 13.3 | 13.3 | 13.10 | 12.87 | 12.43 | 12.17 | 12.22 | 12.22 | 12.22 |
| | CO | 25.7 | 25.7 | 25.7 | 25.27 | 24.80 | 24.07 | 23.45 | 23.60 | 23.60 | 23.60 |
| | $H_2$ | 2.5 | 2.5 | 2.5 | 2.46 | 2.42 | 2.34 | 2.29 | 2.29 | 2.29 | 2.29 |
| | $CH_4$ | 0.1 | .10 | .10 | .10 | .10 | .09 | .09 | .09 | .09 | .09 |
| | $N_2$ | 58.4 | 58.4 | 58.4 | 57.35 | 56.40 | 54.67 | 53.40 | 53.55 | 53.55 | 53.55 |
| | $H_2O$ | .0 | .0 | .0 | 1.72 | 3.41 | 6.38 | 8.60 | 8.25 | 8.25 | 8.25 |
| % Dry Gas in Mixture | | 100 | 100 | 100 | 98.28 | 96.59 | 93.62 | 91.40 | 91.75 | 91.75 | 91.75 |
| Latent Heat Btu/Std. C.F. of Actual Gas | Gross | 92.0 | 92.0 | 92.0 | 90.5 | 88.9 | 86.1 | 84.0 | 84.5 | 84.5 | 84.5 |
| | Net | 90.7 | 90.7 | 90.7 | 89.1 | 87.6 | 84.8 | 82.8 | 83.3 | 83.3 | 83.3 |
| Sensible Heat (Above 60°) Btu/Std. C.F. Actual Gas | | 0 | 2.7 | 6.6 | 0 | .4 | .8 | 1.0 | 2.7 | 4.7 | 6.7 |
| Total Heat Btu/Std. C.F. Actual Gas | Gross | 92.0 | 94.7 | 98.6 | 90.5 | 89.3 | 86.9 | 85.0 | 87.2 | 89.2 | 91.2 |
| | Net | 90.7 | 93.4 | 97.3 | 89.1 | 88.0 | 85.6 | 83.8 | 86.0 | 88.0 | 90.0 |
| Mean Heat Capacity Btu/Std. C.F. Actl. Gas/°F Above 60° | | .01915 | .01932 | .01950 | .01924 | .01927 | .01940 | .01950 | .01957 | .01965 | .01974 |
| Theoretical Air: Combustion C.F. Std. Dry Air/C.F. Std. Act. Gas | | .684 | .684 | .684 | .673 | .662 | .641 | .625 | .628 | .628 | .628 |
| Theoretical Air: Products Std. C.F./C.F. Std. Actual Gas | | 1.551 | 1.551 | 1.551 | 1.543 | 1.534 | 1.518 | 1.505 | 1.506 | 1.506 | 1.506 |
| Theoretical Air: Analysis of Actual Products (Volumetric) Dry | $CO_2$ | 25.2 | 25.2 | 25.2 | 25.0 | 24.6 | 24.2 | 23.8 | 23.8 | 23.8 | 23.8 |
| | $O_2$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | $N_2$ | 72.5 | 72.5 | 72.5 | 71.6 | 70.9 | 69.4 | 68.3 | 68.5 | 68.5 | 68.5 |
| Wet | $H_2O$ | 2.3 | 2.3 | 2.3 | 3.4 | 4.5 | 6.4 | 7.9 | 7.7 | 7.7 | 7.7 |
| Theoretical Air: Flame Temp. (Theor.) (Based on Net Tot. Heat) °F | | 2590 | 2660 | 2755 | 2560 | 2545 | 2510 | 2475 | 2530 | 2575 | 2635 |
| Theoretical Air: Mean Heat Capy. of Products at Theor. Flame Temp. Btu/Std. C.F. Act. Prod. | | .02300 | .02310 | .02320 | .02300 | .02305 | .02308 | .02308 | .02310 | .02320 | .02328 |
| 20% Excess Air: C.F. Std. Dry Air/C.F. Std. Act. Gas | | .821 | .821 | .821 | .807 | .793 | .768 | .750 | .753 | .753 | .753 |
| 20% Excess Air: Products Std. C.F./C.F. Std. Actual Gas | | 1.690 | 1.690 | 1.690 | 1.679 | 1.667 | 1.646 | 1.631 | 1.633 | 1.633 | 1.633 |
| 20% Excess Air: Analysis of Actual Products (Volumetric) Dry | $CO_2$ | 23.1 | 23.1 | 23.1 | 22.9 | 22.7 | 22.3 | 22.0 | 22.0 | 22.0 | 22.0 |
| | $O_2$ | 1.7 | 1.7 | 1.7 | 1.7 | 1.7 | 1.6 | 1.6 | 1.7 | 1.7 | 1.7 |
| | $N_2$ | 73.0 | 73.0 | 73.0 | 72.2 | 71.4 | 70.2 | 69.0 | 69.2 | 69.2 | 69.2 |
| Wet | $H_2O$ | 2.2 | 2.2 | 2.2 | 3.2 | 4.2 | 5.9 | 7.4 | 7.1 | 7.1 | 7.1 |
| 20% Excess Air: Flame Temp. (Theor.) (Based on Net Tot. Heat) °F | | 2435 | 2500 | 2590 | 2415 | 2400 | 2370 | 2330 | 2380 | 2430 | 2490 |
| 20% Excess Air: Mean Heat Capy. of Prod. at Theor. Flame Temp. Btu/Std. C.F. Act. Prod. | | .02261 | .02268 | .02275 | .02260 | .02260 | .02254 | .02266 | .02270 | .02276 | .02280 |
| 40% Excess Air: C.F. Std. Dry Air/C.F. Std. Act. Gas | | .958 | .958 | .958 | .942 | .927 | .897 | .875 | .879 | .879 | .879 |
| 40% Excess Air: Products Std. C.F./C.F. Std. Actual Gas | | 1.827 | 1.827 | 1.827 | 1.815 | 1.801 | 1.778 | 1.760 | 1.760 | 1.760 | 1.760 |
| 40% Excess Air: Analysis of Actual Products (Volumetric) Dry | $CO_2$ | 21.4 | 21.4 | 21.4 | 21.2 | 21.0 | 20.7 | 20.3 | 20.3 | 20.3 | 20.3 |
| | $O_2$ | 3.1 | 3.1 | 3.1 | 3.1 | 3.1 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |
| | $N_2$ | 73.4 | 73.4 | 73.4 | 72.7 | 72.0 | 70.7 | 69.8 | 69.9 | 69.9 | 69.9 |
| Wet | $H_2O$ | 2.1 | 2.1 | 2.1 | 3.0 | 3.9 | 5.6 | 6.9 | 6.8 | 6.8 | 6.8 |
| 40% Excess Air: Flame Temp. (Theor.) (Based on Net Tot. Heat) °F | | 2290 | 2355 | 2450 | 2270 | 2255 | 2225 | 2185 | 2245 | 2290 | 2345 |
| 40% Excess Air: Mean Heat Capy. of Prod. at Theor. Flame Temp. Btu/Std. C.F. Act. Prod. | | .02222 | .02235 | .02245 | .02227 | .02237 | .02220 | .02230 | .02231 | .02233 | .02240 |

Note: Combustion Criteria Shown Graphically on Figs. 5-a and -b

## TABLE VIII-a

## STACK LOSSES WITH 92 BTU BLAST FURNACE GAS

| | | Stack gas temp F | Dry gas | | | Saturated gas | | | | Hot gas with 30 grains $H_2O$ per cu ft std dry gas | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 60 F | 200 F | 400 F | 60 F | 80 F | 100 F | 110 F | 200 F | 300 F | 400 F |
| Theoretical air | Mean heat capacity of products above 60 F (Btu/cu ft/deg) | 300 | .02027 | .02027 | .02027 | .02032 | .02033 | .02037 | .02040 | .02040 | .02040 | .02040 |
| | | 500 | .02056 | .02056 | .02056 | .02059 | .02059 | .02062 | .02067 | .02065 | .02065 | .02065 |
| | | 700 | .02080 | .02080 | .02080 | .02082 | .02083 | .02090 | .02091 | .02091 | .02091 | .02091 |
| | Per cent stack loss | 300 | 8.3 | 8.1 | 7.8 | 8.4 | 8.5 | 8.7 | 8.8 | 8.6 | 8.4 | 8.2 |
| | | 500 | 15.5 | 15.1 | 14.4 | 14.9 | 15.8 | 16.1 | 16.3 | 15.9 | 15.5 | 15.2 |
| | | 700 | 22.8 | 22.2 | 21.3 | 23.0 | 23.2 | 23.8 | 24.0* | 23.4 | 22.9 | 22.4 |
| 20% Excess air | Mean heat capacity of products above 60 F (Btu/cu ft/deg) | 300 | .02013 | .02013 | .02013 | .02018 | .02020 | .02023 | .02029 | .02026 | .02026 | .02026 |
| | | 500 | .02040 | .02040 | .02040 | .02041 | .02044 | .02049 | .02053 | .02050 | .02050 | .02050 |
| | | 700 | .02064 | .02064 | .02064 | .02066 | .02068 | .02072 | .02078 | .02077 | .02077 | .02077 |
| | Per cent stack loss | 300 | 9.0 | 8.7 | 8.4 | 9.1 | 9.2 | 9.3 | 9.5 | 9.2 | 9.0 | 8.8 |
| | | 500 | 16.8 | 16.3 | 15.6 | 16.9 | 17.0 | 17.3 | 17.6 | 17.1 | 16.7 | 16.4 |
| | | 700 | 24.6 | 23.9 | 23.0 | 24.8 | 25.1 | 25.4 | 25.9 | 25.2 | 24.7 | 24.1 |
| 40% Excess air | Mean heat capacity of products above 60 F (Btu/cu ft/deg) | 300 | .02004 | .02004 | .02004 | .02005 | .02005 | .02008 | .02014 | .02014 | .02014 | .02014 |
| | | 500 | .02028 | .02028 | .02028 | .02028 | .02031 | .02032 | .02038 | .02038 | .02038 | .02038 |
| | | 700 | .02050 | .02050 | .02050 | .02051 | .02052 | .02058 | .02060 | .02060 | .02060 | .02060 |
| | Per cent stack loss | 300 | 9.7 | 9.4 | 9.0 | 9.8 | 9.9 | 10.0 | 10.2 | 9.9 | 9.7 | 9.6 |
| | | 500 | 17.9 | 17.5 | 16.7 | 18.1 | 18.3 | 18.5 | 18.8 | 18.4 | 17.9 | 17.5 |
| | | 700 | 26.5 | 25.7 | 24.6 | 26.7 | 26.9 | 27.3 | 27.5 | 27.0 | 26.4 | 25.8 |

### UTILIZATION OF THE DATA

We close this dissertation with a specimen problem involving the combustion of blast furnace gas. The purpose is to bring out the practical use of the data hereabove developed.

A heat balance is being conducted on a fine, new hot-blast stove. Those interested are the combustion department, the engineering department and the blast furnace department. The first is represented at the test by a young man just out of college. He forgets all about moisture and humidity. The representative of the Engineering Department is well aware of his humidity. He takes it out in figuring gas quantities and analyses, but he forgets to put it in again in figuring combustion conditions. The blast furnace man (as all blast furnace men know full well), figures it correctly. These characters and their roles can be changed about to suit any group sympathies.

The following conditions and general data are observed and logged by all concerned:

Size of stove ..... 25 ft diameter x 110 ft high
Stove cycle:
Gas period ..... 160 minutes
Blast period ..... 90 minutes
Change period ..... 20 minutes
270 minutes (equals 4½ hr)

Cold blast temperature ..... 150 F
Hot blast temperature ..... 1350 F
Average stack temperature ..... 300 F
Fuel gas temperature ..... 100 F
Outside air temperature ..... 60 F

Samples of fuel gas and stack gas are taken and analyzed out of doors. The analysis apparatus reports the following averages:

| Fuel gas, per cent | | Stack gas, per cent |
|---|---|---|
| 13.10 | $CO_2$ | 23.5 |
| 25.27 | CO | 0 |
| 2.46 | $H_2$ | ..... |
| .10 | $CH_4$ | ..... |
| 0 | $O_2$ | 1.68 |
| 59.07 | $N_2$ (by difference) | 74.82 |
| 100.00 | | 100.00 |

A reliable meter has been installed, and the gas rate, after correcting for temperature and pressure, is shown to average 12,300 cu ft per minute (at 60 F and 30 in. Hg).

Just before the three calculators retire to their respective desks, they agree that the most accurate figure of radiation loss for this stove is as follows:

1,290,000 Btu per hr × 1.25 for air velocity
× 4.5 hr cycle equals 7,200,000 Btu

They also agree that the mean heat capacity of the hot blast is 0.0191 Btu per cu ft per degree F as given in "Combustion," Industrial Gas Series, American Gas Association, 1932, accordingly the total heat abstracted by the blast is:

70,000 cfm × 90 min × (1350—150 F)
× 0.0191, or 144,600,000 Btu

From here on, the three computers compute conscientiously (Table X). A is the man who forgets entirely about humidity; B takes it out, but forgets to put it in again when needed; C figures the matter correctly. (Interested observers can follow the intrigue by taking recourse to Tables VI, VIII and VIII-a).

## TABLE IX

### CHARACTERISTICS OF 98 BTU BLAST FURNACE GAS

| "STANDARD" GAS - AS OF 60°F X 30" Hg<br>"DRY" GAS - NO WATER VAPOR<br>"ACTUAL" GAS - INCLUDES WATER VAPOR<br>AIR ASSUMED HAS 4GR $H_2O$/STD DRY C.F. | | DRY GAS | | | SATURATED GAS | | | | HOT GAS WITH 30 GR $H_2O$ PER C.F. STD DRY GAS | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 60°F | 200 | 400 | 60°F | 80 | 100 | 110 | 200°F | 300 | 400 |
| GRAINS $H_2O$/C.F. STD DRY GAS | | 0 | 0 | 0 | 5.84 | 11.77 | 22.7 | 31.3 | 30 | 30 | 30 |
| C.F. $H_2O$/C.F. STD DRY GAS | | 0 | 0 | 0 | .0175 | .0353 | .0682 | .0940 | .090 | .090 | .090 |
| ANALYSIS OF ACTUAL GAS - VOLUMETRIC - PER CENT | $CO_2$ | 11.5 | 11.5 | 11.5 | 11.31 | 11.11 | 10.77 | 10.32 | 10.57 | 10.57 | 10.57 |
| | CO | 27.5 | 27.5 | 27.5 | 27.06 | 26.56 | 25.75 | 25.10 | 25.25 | 25.25 | 25.25 |
| | $H_2$ | 2.5 | 2.5 | 2.5 | 2.46 | 2.42 | 2.34 | 2.29 | 2.29 | 2.29 | 2.29 |
| | $CH_4$ | 0.1 | 0.1 | 0.1 | 0.10 | 0.10 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 |
| | $N_2$ | 58.4 | 58.4 | 58.4 | 57.35 | 56.00 | 54.67 | 53.40 | 53.55 | 53.55 | 53.55 |
| | $H_2O$ | 0 | 0 | 0 | 1.72 | 3.41 | 6.38 | 8.60 | 8.25 | 8.25 | 8.25 |
| % DRY GAS IN MIXTURE | | 100 | 100 | 100 | 98.28 | 96.59 | 93.62 | 91.40 | 91.75 | 91.75 | 91.75 |
| LATENT HEAT BTU/STD. C.F. OF ACTUAL GAS | GROSS | 97.7 | 97.7 | 97.7 | 96.5 | 94.3 | 91.6 | 89.3 | 89.8 | 89.8 | 89.8 |
| | NET | 96.4 | 96.4 | 96.4 | 94.9 | 93.0 | 90.3 | 88.1 | 88.6 | 88.6 | 88.6 |
| SENSIBLE HEAT (ABOVE 60°) BTU/STD. C.F. ACTUAL GAS | | 0 | 2.7 | 6.6 | 0 | 4 | .8 | 1.0 | 2.7 | 4.7 | 6.7 |
| TOTAL HEAT BTU/STD. C.F. ACTUAL GAS | GROSS | 97.7 | 100.4 | 104.3 | 96.5 | 94.7 | 92.4 | 90.3 | 92.5 | 94.5 | 96.5 |
| | NET | 96.4 | 99.1 | 103.0 | 94.9 | 93.4 | 91.1 | 89.1 | 91.3 | 93.3 | 95.3 |
| MEAN HEAT CAPACITY BTU/STD. C.F. ACT. GAS/°F ABOVE 60° | | .01908 | .01923 | .01940 | .01911 | .01919 | .01930 | .01940 | .01946 | .01955 | .01963 |
| COMBUSTION C.F. STD. DRY AIR/C.F. STD. ACT. GAS | | .728 | .728 | .728 | .716 | .703 | .682 | .664 | .668 | .668 | .668 |
| THEORETICAL AIR | PRODUCTS STD. C.F./C.F. STD. ACTUAL GAS | 1.587 | 1.587 | 1.587 | 1.577 | 1.567 | 1.549 | 1.535 | 1.539 | 1.539 | 1.539 |
| | ANALYSIS OF PRODUCTS (VOLUMETRIC PER CENT) $CO_2$ | 24.7 | 24.7 | 24.7 | 24.5 | 24.2 | 23.6 | 23.3 | 23.4 | 23.4 | 23.4 |
| | ACTUAL $O_2$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | $N_2$ | 73.0 | 73.0 | 73.0 | 72.2 | 71.4 | 70.1 | 68.9 | 69.1 | 69.1 | 69.1 |
| | $H_2O$ | 2.3 | 2.3 | 2.3 | 3.3 | 4.4 | 6.3 | 7.8 | 7.5 | 7.5 | 7.5 |
| | FLAME TEMP. (THEOR.) (BASED ON NET TOT. HEAT) °F | 2685 | 2755 | 2855 | 2665 | 2635 | 2590 | 2555 | 2620 | 2675 | 2715 |
| | MEAN HEAT CAPY. OF PRODUCTS AT THEOR. FLAME TEMP. BTU/STD. C.F. ACT. PROD. | .02306 | .02312 | .02320 | .02305 | .02310 | .02315 | .02305 | .02320 | .02322 | .02330 |
| 20% EXCESS AIR | C.F. STD. DRY AIR/C.F. STD. ACT. GAS | .874 | .874 | .874 | .859 | .844 | .818 | .797 | .802 | .802 | .802 |
| | PRODUCTS STD. C.F./C.F. STD. ACTUAL GAS | 1.734 | 1.734 | 1.734 | 1.7222 | 1.709 | 1.687 | 1.669 | 1.672 | 1.672 | 1.672 |
| | ANALYSIS OF PRODUCTS (VOLUMETRIC PER CENT) $CO_2$ | 22.5 | 22.5 | 22.5 | 22.4 | 22.1 | 21.7 | 21.4 | 21.4 | 21.4 | 21.4 |
| | ACTUAL $O_2$ | 1.8 | 1.8 | 1.8 | 1.7 | 1.7 | 1.6 | 1.6 | 1.6 | 1.6 | 1.6 |
| | $N_2$ | 73.5 | 73.5 | 73.5 | 72.7 | 72.1 | 70.8 | 69.8 | 70.0 | 70.0 | 70.0 |
| | $H_2O$ | 2.2 | 2.2 | 2.2 | 3.2 | 4.1 | 5.9 | 7.2 | 7.0 | 7.0 | 7.0 |
| | FLAME TEMP. (THEOR.) (BASED ON NET TOT. HEAT) °F | 2520 | 2580 | 2665 | 2495 | 2470 | 2440 | 2405 | 2460 | 2510 | 2560 |
| | MEAN HEAT CAPY. OF PROD. AT THEOR. FLAME TEMP. BTU/STD. C.F. ACT. PROD. | .02255 | .02270 | .02280 | .02265 | .02265 | .02267 | .02265 | .02265 | .02275 | .02280 |
| 40% EXCESS AIR | C.F. STD. DRY AIR/C.F. STD. ACT. GAS | 1.019 | 1.019 | 1.019 | 1.002 | .984 | .955 | .930 | .935 | .935 | .935 |
| | PRODUCTS STD. C.F./C.F. STD. ACTUAL GAS | 1.882 | 1.882 | 1.882 | 1.867 | 1.851 | 1.825 | 1.804 | 1.809 | 1.809 | 1.809 |
| | ANALYSIS OF PRODUCTS (VOLUMETRIC PER CENT) $CO_2$ | 20.7 | 20.7 | 20.7 | 20.6 | 20.4 | 20.0 | 19.8 | 19.8 | 19.8 | 19.8 |
| | ACTUAL $O_2$ | 3.2 | 3.2 | 3.2 | 3.2 | 3.2 | 3.1 | 3.1 | 3.1 | 3.1 | 3.1 |
| | $N_2$ | 74.0 | 74.0 | 74.0 | 73.2 | 72.5 | 71.4 | 70.3 | 70.6 | 70.6 | 70.6 |
| | $H_2O$ | 2.1 | 2.1 | 2.1 | 3.0 | 3.9 | 5.5 | 6.8 | 6.5 | 6.5 | 6.5 |
| | FLAME TEMP. (THEOR.) (BASED ON NET TOT. HEAT) °F | 2365 | 2420 | 2510 | 2340 | 2320 | 2300 | 2270 | 2315 | 2355 | 2410 |
| | MEAN HEAT CAPY. OF PROD. AT THEOR. FLAME TEMP. BTU/STD. C.F. ACT. PROD. | .02220 | .02230 | .02238 | .02225 | .02228 | .02228 | .02225 | .02235 | .02240 | .02245 |

NOTE: COMBUSTION CRITERIA SHOWN GRAPHICALLY ON FIGS. 6-a AND -b

## TABLE IX-a

## STACK LOSSES WITH 98 BTU BLAST FURNACE GAS

| | | Stack gas temp F | Dry gas | | | Saturated gas | | | | Hot gas with 30 grains $H_2O$ per cu ft std dry gas | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 60 F | 200 F | 400 F | 60 F | 80 F | 100 F | 110 F | 200 F | 300 F | 400 F |
| Theoretical air | Mean heat capacity of products above 60 F (Btu/cu ft/deg) | 300 | .02023 | .02023 | .02023 | .02026 | .02030 | .02031 | .02036 | .02037 | .02037 | .02037 |
| | | 500 | .02050 | .02050 | .02050 | .02054 | .02058 | .02060 | .02062 | .02058 | .02058 | .02058 |
| | | 700 | .02075 | .02075 | .02075 | .02077 | .02080 | .02083 | .02085 | .02082 | .02082 | .02082 |
| | Per cent stack loss | 300 | 8.0 | 7.8 | 7.5 | 8.1 | 8.2 | 8.3 | 8.4 | 8.2 | 8.0 | 7.96 |
| | | 500 | 14.9 | 14.4 | 13.9 | 15.0 | 15.2 | 15.4 | 15.7 | 15.2 | 14.9 | 14.6 |
| | | 700 | 21.9 | 21.2 | 20.5 | 22.0 | 22.4 | 22.7 | 23.1 | 22.4 | 22.0 | 21.5 |
| 20% Excess air | Mean heat capacity of products above 60 F (Btu/cu ft/deg) | 300 | .02010 | .02010 | .02010 | .02014 | .02015 | .02018 | .02021 | .02019 | .02019 | .02019 |
| | | 500 | .02035 | .02035 | .02035 | .02042 | .02043 | .02044 | .02049 | .02047 | .02047 | .02047 |
| | | 700 | .02058 | .02058 | .02058 | .02064 | .02065 | .02068 | .02070 | .02068 | .02068 | .02068 |
| | Per cent stack loss | 300 | 8.7 | 8.4 | 8.1 | 8.4 | 8.8 | 9.0 | 9.1 | 8.9 | 8.7 | 8.5 |
| | | 500 | 16.1 | 15.7 | 15.1 | 16.3 | 16.5 | 16.7 | 16.8 | 16.5 | 16.2 | 15.8 |
| | | 700 | 23.7 | 23.0 | 22.2 | 24.0 | 24.2 | 24.5 | 24.8 | 24.2 | 23.7 | 23.2 |
| 40% Excess air | Mean heat capacity of products above 60 F (Btu/cu ft/deg) | 300 | .01995 | .01995 | .01995 | .01999 | .02001 | .02005 | .02007 | .02004 | .02004 | .02004 |
| | | 500 | .02022 | .02022 | .02002 | .02026 | .02026 | .02029 | .02035 | .02031 | .02031 | .02031 |
| | | 700 | .02043 | .02043 | .02043 | .02047 | .02048 | .02052 | .02057 | .02052 | .02052 | .02052 |
| | Per cent stack loss | 300 | 9.3 | 9.1 | 8.7 | 9.4 | 9.6 | 9.7 | 9.8 | 9.5 | 9.3 | 9.1 |
| | | 500 | 17.4 | 16.9 | 16.3 | 17.4 | 17.7 | 17.9 | 18.1 | 17.7 | 17.3 | 17.0 |
| | | 700 | 25.5 | 24.9 | 23.9 | 25.6 | 26.0 | 26.2 | 26.6 | 26.8 | 26.2 | 25.7 |

## TABLE X

| | A | B | C |
|---|---|---|---|
| **Gas fired to the stove** | | | |
| Rate, cfm | 11,520 | 12,300 | 12,300 |
| $CO_2$, per cent | 13.3 | 13.10 | 12.45 |
| CO, per cent | 25.7 | 25.27 | 24.07 |
| $H_2$, per cent | 2.5 | 2.46 | 2.34 |
| $CH_4$, per cent | 0.10 | 0.10 | 0.09 |
| $N_2$, (diff) per cent | 58.4 | 59.07 | 54.67 |
| $H_2O$, per cent | 0 | ... | 6.38 |
| | 100.00 | 100.00 | 100.00 |
| Latent heat — gross | 92.0 | 90.5 | 86.1 |
| (Btu per cu ft) — net | 90.7 | 89.1 | 84.8 |
| Sensible heat | 0.8 | 0.8 | 0.8 |
| Total heat — gross | 92.8 | 91.3 | 86.9 |
| Total heat — net | 91.5 | 89.9 | 85.6 |
| **Stack gas** | | | |
| $CO_2$, per cent | 23.83 | 23.5 | 22.3 |
| $O_2$, per cent | 1.71 | 1.68 | 1.6 |
| $N_2$, (diff) per cent | 74.46 | 74.82 | 70.2 |
| $H_2O$, per cent | 0 | ... | 5.9 |
| Mean heat capacity (Btu per cu ft per degree F) | 0.02013 | 0.02013 | 0.02023 |
| **Per cent stack loss** | | | |
| $\frac{CO+CO_2 \text{ in fuel gas}}{CO+CO_2 \text{ in stack gas}} \times (300-60) \times \text{mean heat capacity} \times 100 = \frac{}{\text{Total net heat in fuel gas}}$ | 8.62% | 8.8% | 9.3% |
| **Heat balance (Btu per cycle)** | | | |
| Total heat input (cfm gas rate × 160 min × total net heat per cu ft) | 169,200,000 | 177,000,000 | 168,500,000 |
| Heat to blast | 144,600,000 | 144,600,000 | 144,600,000 |
| Heat to stack (per cent stack loss × total heat input) | 14,600,000 | 15,600,000 | 15,650,000 |
| Radiation loss | 7,200,000 | 7,200,000 | 7,200,000 |
| Unaccounted (by diff) | 2,800,000 | 9,600,000 | 1,050,000 |
| Total heat output | 169,200,000 | 177,000,000 | 168,500,000 |
| **Heat balance (per cent)** | | | |
| Stove efficiency | 85.50 | 81.70 | 85.80 |
| Stack loss | 8.62 | 8.80 | 9.30 |
| Radiation loss | 4.24 | 4.07 | 4.27 |
| Unaccounted | 1.64 | 5.43 | 0.63 |
| | 100.00 | 100.00 | 100.00 |

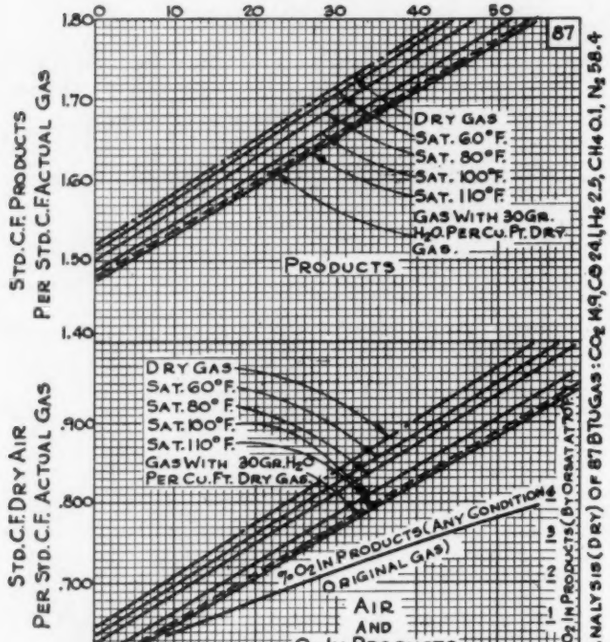

87
STD. C.F. PRODUCTS PER STD. C.F. ACTUAL GAS
STD. C.F. DRY AIR PER STD. C.F. ACTUAL GAS
DRY GAS
SAT. 60°F.
SAT. 80°F.
SAT. 100°F.
SAT. 110°F.
GAS WITH 30 GR. H2O PER CU. FT. DRY GAS.
PRODUCTS
% O2 IN PRODUCTS (ANY CONDITION ORIGINAL GAS)
AIR AND O2 IN PRODUCTS
ANALYSIS (DRY) OF 87 BTU GAS: CO2 14.9, CO 24.1, H2 2.5, CH4 0.1, N2 58.4
PERCENT EXCESS AIR (AIR AT 60°F. x 30" Hg x DRY)

**Figure 4a — Characteristics of 87 Btu blast furnace gas, air and combustion products ratios with 4 grains $H_2O$ assumed with each cu ft dry air.**

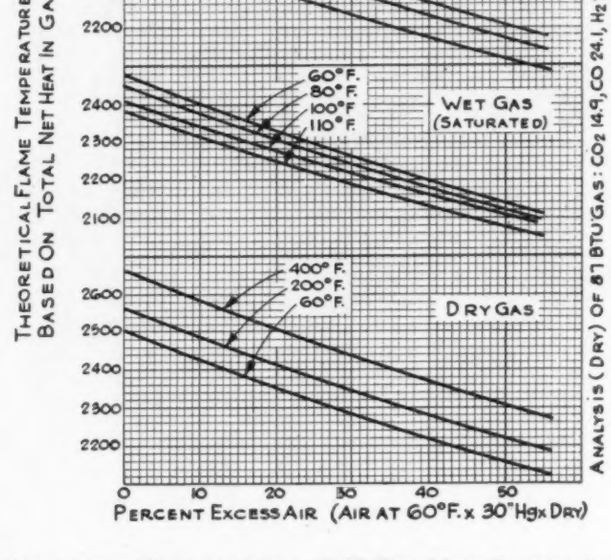



**Figure 4b — Characteristics of 87 Btu blast furnace gas giving theoretical flame temperature, assuming 4 grains $H_2O$ with each cu ft dry air.**

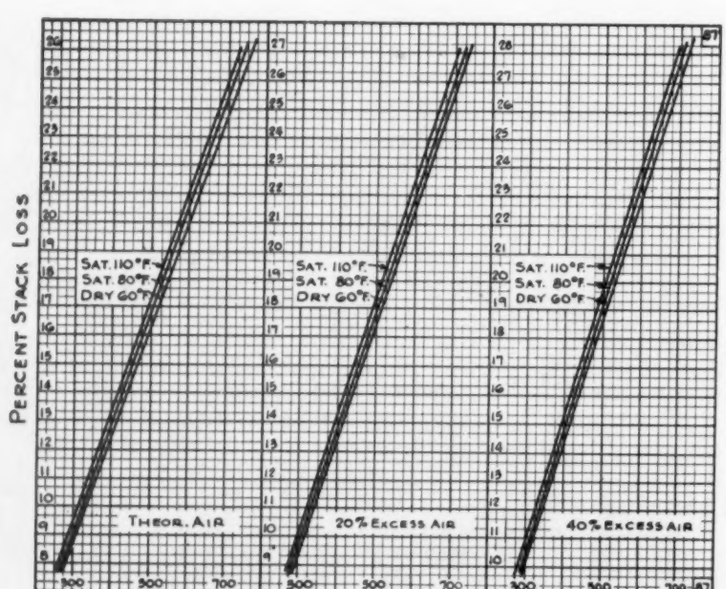



**Figure 4c — Per cent stack loss for 87 Btu blast furnace gas.**

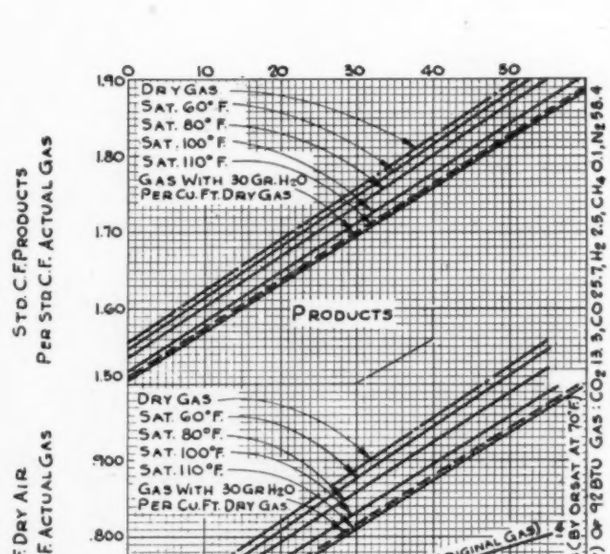

STD. C.F. PRODUCTS PER STD. C.F. ACTUAL GAS
STD. C.F. DRY AIR PER STD. C.F. ACTUAL GAS
DRY GAS
SAT. 60°F.
SAT. 80°F.
SAT. 100°F.
SAT. 110°F.
GAS WITH 30 GR. H2O PER CU. FT. DRY GAS
PRODUCTS
% O2 IN PRODUCTS (ANY CONDITION ORIGINAL GAS)
AIR AND O2 IN PRODUCTS
ANALYSIS (DRY) OF 92 BTU GAS: CO2 13.3, CO 25.7, H2 2.5, CH4 0.1, N2 58.4
PERCENT EXCESS AIR (AIR AT 60°F. x 30" Hg x DRY)

**Figure 5a — Characteristics of 92 Btu blast furnace gas, air and combustion products ratios with 4 grains $H_2O$ assumed with each cu ft dry air.**

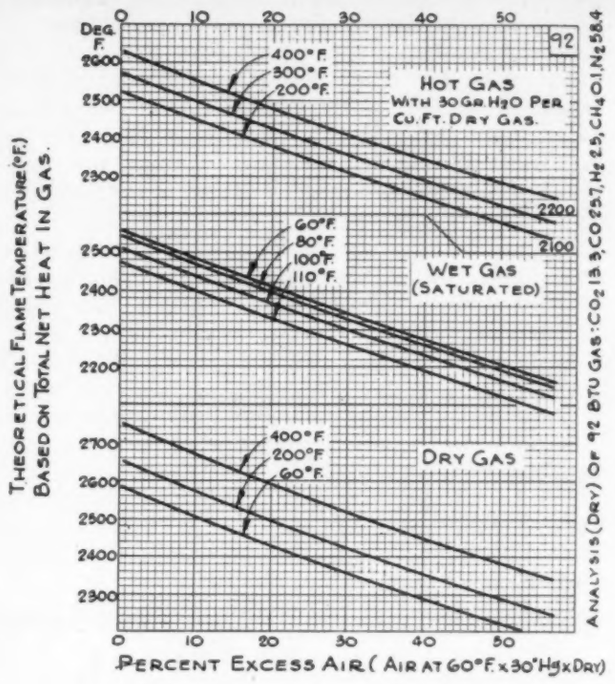

THEORETICAL FLAME TEMPERATURE (°F.) BASED ON TOTAL NET HEAT IN GAS.
DEG. F.
92
400° F.
300° F.
200° F.
HOT GAS WITH 30 GR H2O PER CU. FT. DRY GAS.
2200
2100
60° F.
80° F.
100° F.
110° F.
WET GAS (SATURATED)
400° F.
200° F.
60° F.
DRY GAS
ANALYSIS (DRY) OF 92 BTU GAS: CO2 13.3, CO 25.7, H2 2.5, CH4 0.1, N2 58.4
PERCENT EXCESS AIR (AIR AT 60° F. x 30" Hg x DRY)

**Figure 5b — Characteristics of 92 Btu blast furnace gas giving theoretical flame temperature, assuming 4 grains $H_2O$ with each cu ft dry air.**

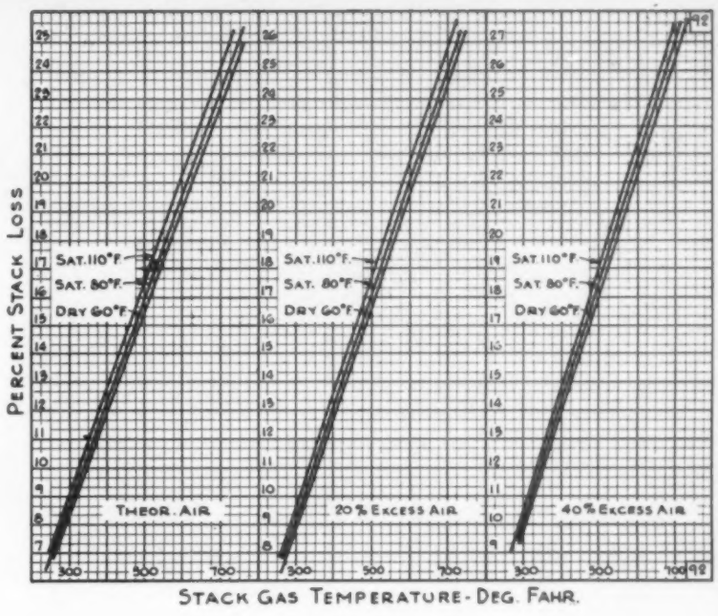



**Figure 5c — Per cent stack loss for 92 Btu blast furnace gas.**

C shows the correct heat balance for the stove. A comes out very closely on his stove efficiency figure, but he is quite a little in error on his stack loss. He is content to brush off the 1.64 per cent unaccounted loss. B is badly off on stove efficiency, and he faces with considerable embarrassment the prospect of having to "eat" some 5 per cent of unaccounted heat before submitting his report.

So long as a specific figure for radiation is not set up, the caption "Radiation and Unaccounted" is often a comfortable repository for loose ends. But B can hardly get by with almost 10 per cent in this bracket for a modern stove, and an efficiency figure not very much higher, perhaps, than the old stove that the new one replaced.

Of further interest to steel plant combustion engineers and to blast furnace operators will be a reference to the effect of excess air. Schooled as many are in boiler lore, we have regarded excess air as a thing to be avoided — as the arch enemy of efficiency and rating. This is substantially true in boiler practice. When the modern hot-blast stove of high efficiency and great thermal capacity came into being with its accurately regulating pressure burner, it was often felt that the combustion department should keep a paternal but tactful eye on such unusually advanced equipment suddenly thrown to the tender mercies of the blast furnace operator. Presently the blast furnace man, concerned with the over-heating of his checkers due to the not altogether foreseen effects of clean gas, suggested the cutting of flame temperatures by introducing excess air at the burner. Some of the combustion people saw in such procedure the desecration of all that they believed right and true. However, a scrutiny of the data here

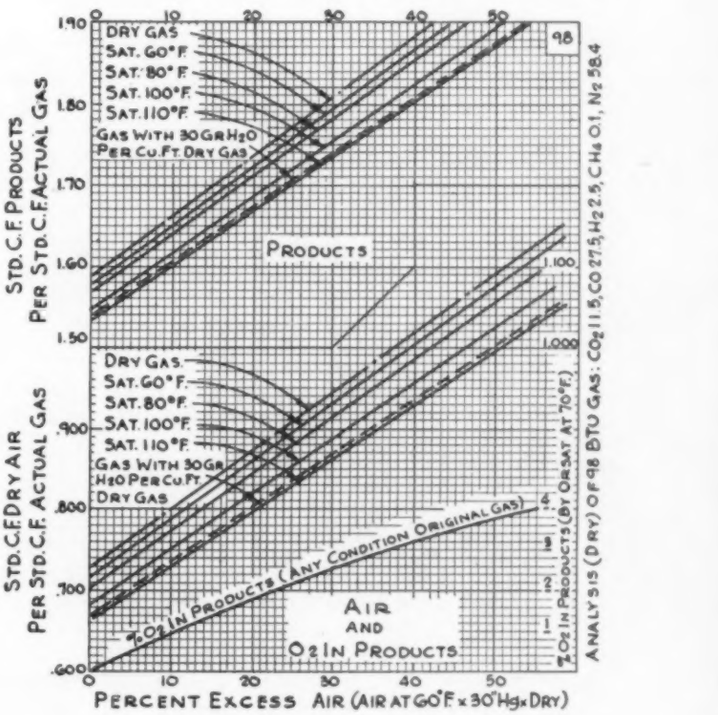

STD. C.F. PRODUCTS PER STD. C.F. ACTUAL GAS
STD. C.F. DRY AIR PER STD. C.F. ACTUAL GAS
98
DRY GAS
SAT. 60° F.
SAT. 80° F.
SAT. 100° F.
SAT. 110° F.
GAS WITH 30 GR H2O PER CU. FT. DRY GAS
PRODUCTS
DRY GAS
SAT. 60° F.
SAT. 80° F.
SAT. 100° F.
SAT. 110° F.
GAS WITH 30 GR H2O PER CU. FT. DRY GAS
% O2 IN PRODUCTS (ANY CONDITION ORIGINAL GAS)
AIR AND O2 IN PRODUCTS
% O2 IN PRODUCTS (BY ORSAT AT 70° F.)
ANALYSIS (DRY) OF 98 BTU GAS: CO2 11.5, CO 27.5, H2 2.5, CH4 0.1, N2 58.4
PERCENT EXCESS AIR (AIR AT 60° F. x 30" Hg x DRY)

**Figure 6a — Characteristics of 98 Btu blast furnace gas, air and combustion products ratios with 4 grains $H_2O$ assumed with each cu ft dry air.**

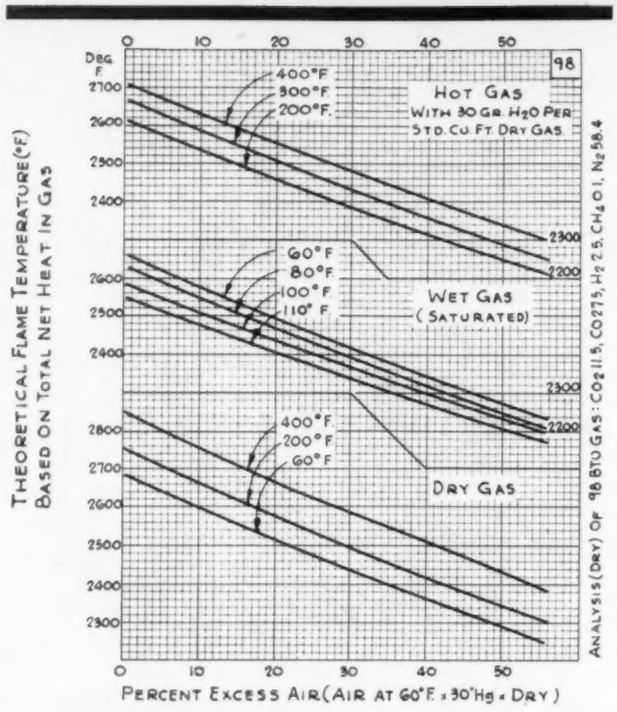
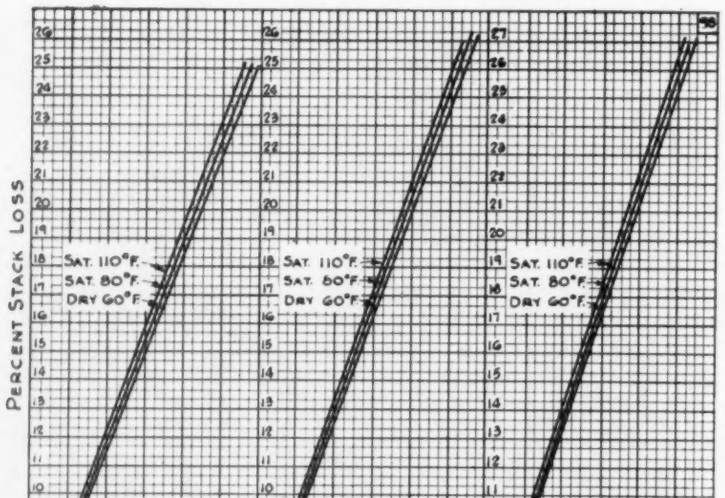



**Figure 6b — Characteristics of 98 Btu blast furnace gas giving theoretical flame temperature, assuming 4 grains $H_2O$ with each cu ft dry air.**

▲

**Figure 6c — Per cent stack loss for 98 Btu blast furnace gas**




presented will disclose that in introducing excess air into hot blast stoves, all is not lost; efficiency may not be altogether devastated. Typical modern hot-blast stove combustion involves about 20 per cent excess air, and results in a stack gas temperature of about 300 F. A glance at Figure 5c will show that with 92 Btu wet-washed gas at 80 F (typical stove fuel), there is a stack loss of 9.2 per cent. Figure 5b shows a theoretical flame temperature of 2400 F. Whether or not this flame temperature is actually attained, let us say that the furnace operator wants to reduce it to a theoretical 2250 F, a drop of 150 degrees. Figure 5b shows that he will have to increase the excess air to 40 per cent. Reference to Figure 5c shows that the stack loss would go up to 9.9 per cent if the stack temperature remained at 300 F. But a 150 degree decrease in flame temperature will certainly have some depressing influence on stack temperature, and it need drop only 15 degrees in order to restore the stack loss to the original 9.2 per cent (see Figure 5c).

The penalty for using excess air to cut flame temperature in hot blast stoves resides not so much in the loss of efficiency as in the reduction in the attainable blast heat intensity. The operator in the above example may have to be content with 1450 F blast instead of 1600 F.

Probably many blast furnace men and combustion engineers already have much of the above material or its equivalent at their fingertips. There may be some, however, who do not, or who may be not altogether satisfied with what they have. The material has proved useful to the writer through many years. It is hoped that, as a piece for reference, it will prove similarly useful to others.

## *Clark* DISCUSSION

(*Continued from page 63*)

**H. T. Clark:** That effect is rather small, and we have not detected it to a measurable degree in our work. I think Mr. Sordahl has also done some work on this subject.

**L. O. Sordahl:** We have used the Collins-Oseland tube method from 0.03 to 2.30 per cent carbon and have found there is a very slight change in temperature readings with changing carbon. Since there were several other dependent factors involved with the change in carbon and the measured trend was of very small numerical magnitude, we are ignoring the effect in daily use until the various factors can be isolated or controlled and their effect measured.

**H. T. Clark:** I think it is probably significant also in this connection that, if you are working with a certain carbon heat, you are interested in obtaining a certain temperature reading for the best results, and if there is any slight effect on the temperature reading due to combustion of carbon by the air, that effect should be constant for that particular carbon steel. So while on an absolute basis you may get an effect, on a relative basis it is not significant.

**D. G. Harris:** I would like to know if there has been a study of the British platinum couple, its construction and use in comparison with the Rustless couple? Can one use the British and the Rustless couples and get the same results? Is the British construction more simple? I think, also, that the British couple has a thinner wall silica tube; will the thinner walled silica tube help us in taking our readings?

**H. T. Clark:** I think either construction would work quite satisfactorily. It should not affect the reading of your thermocouple.

So far as thinner or thicker walled silica tubes are concerned, you will probably get a more rapid response with the thin walled one and, if the bead of the thermocouple is in contact with the quartz tube, that will also speed up your reading.

# MODERN *Distribution Systems* FOR STEEL MILLS

***. . . . modernization in steel plants and plant additions normally entail additional loads on the power system . . . . in the following paper, Mr. Bloomquist covers the planning and design of a distribution system which is economical and which will provide for future expansion . . . .***

*by W. C. Bloomquist*

GENERAL ELECTRIC COMPANY

SCHENECTADY, NEW YORK

▲ MANY of the steel mills are considering modernizing existing electrical systems and planning future expansion programs. One of the big problems associated with such projects is providing an adequate, economical and operable power system.

Most of the steel mill utilization equipment is more or less pegged at 6600, 2300, or 440 volts (with some large drives at 13,200 volts) and in all likelihood will continue at these voltages, so any plan of expansion or modification must consider existing voltage levels.

The nature of a steel mill load and process requires a high degree of service continuity so dual or multiple power feeds to each load area are common. In order to render maximum service, to take advantage of diversity among loads, centralize operation, and to realize the minimum investment in standby capacity, it is desirable to have a common power bus, or its equivalent.

All too often distribution systems are designed without sufficient attention to the operating problems. Even though a power system is large in capacity, and seemingly complicated, the operating functions, whether generation, distribution, switching or control, can and should be simple. Generally, systems are difficult to operate because they were not planned as part of a simple coordinated project.

It is rather difficult to try to discuss the broad subject of power distribution systems in a single article, so rather than discuss generalities, an actual case study will be analyzed. This example may not fit all cases, but it does include many of the important factors to be considered for any mill power system.

Presented before A. I. S. E. Cleveland-Youngstown District Sec. Meeting, Mar.19, 20, '45

## THE PROBLEM

A company had its own generating station with generation and main distribution at 6900 volts.

The problem was to lay out a power system for a total future capacity of 150,000 kw but arranged in a "building block" style so the facilities could be added as the load grew over a 10 year period. Flexibility for load growth and ease of installation with a minimum amount of interruption to service were of extreme importance. An important additional factor in the planning was the physical arrangement of the electrical power equipment and the distribution system proper.

Some of the factors governing the selection of the ultimate arrangement were:

1. Total system capacity.
2. Selection of generation, distribution, and utilization voltage levels.
3. Physical arrangement.
4. Adaptability to future expansion or change.
5. System protection.

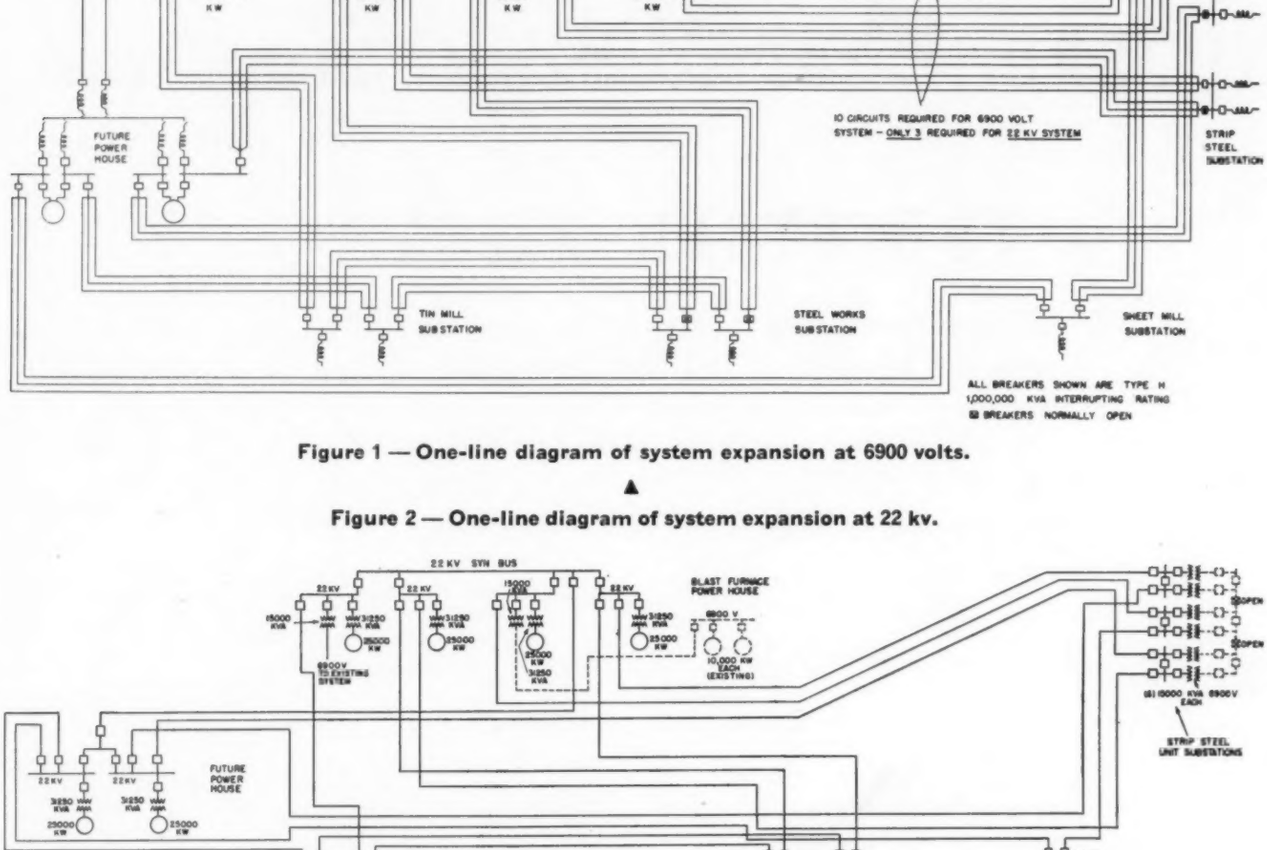
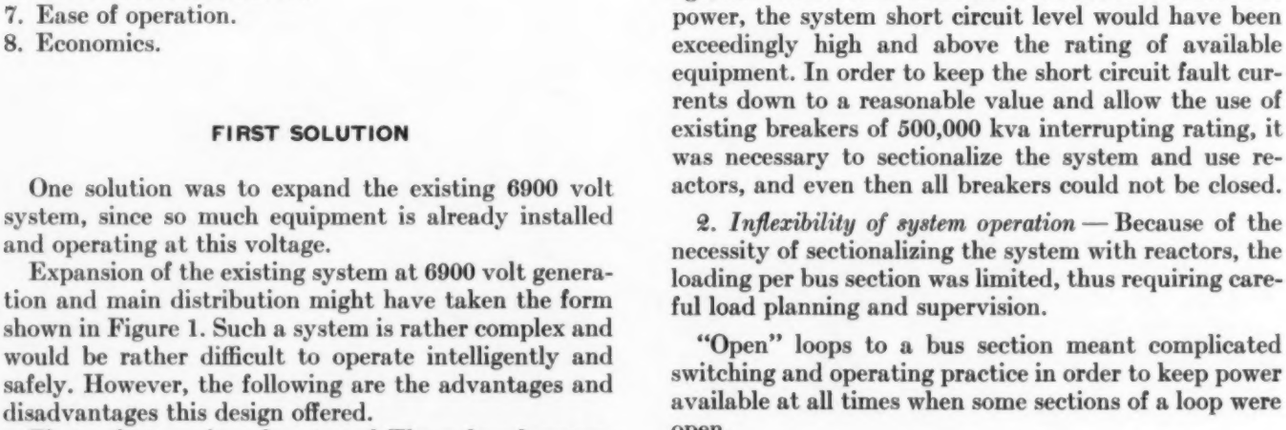

BLAST FURNACE POWER HOUSE
28 BREAKERS REQUIRED FOR 6900 VOLTS
ONLY 17 REQUIRED FOR 22 KV SYSTEM
EXISTING GENERATORS
25000 KW
25000 KW
25000 KW
25000 KW
10 CIRCUITS REQUIRED FOR 6900 VOLT SYSTEM – ONLY 3 REQUIRED FOR 22 KV SYSTEM
FUTURE POWER HOUSE
STRIP STEEL SUBSTATION
TIN MILL SUBSTATION
STEEL WORKS SUBSTATION
SHEET MILL SUBSTATION
ALL BREAKERS SHOWN ARE TYPE H
1,000,000 KVA INTERRUPTING RATING
BREAKERS NORMALLY OPEN

**Figure 1 — One-line diagram of system expansion at 6900 volts.**

▲

**Figure 2 — One-line diagram of system expansion at 22 kv.**




6. Short circuit fault levels.
7. Ease of operation.
8. Economics.

## FIRST SOLUTION

One solution was to expand the existing 6900 volt system, since so much equipment is already installed and operating at this voltage.

Expansion of the existing system at 6900 volt generation and main distribution might have taken the form shown in Figure 1. Such a system is rather complex and would be rather difficult to operate intelligently and safely. However, the following are the advantages and disadvantages this design offered.

First, what are its advantages? The only advantage is that the design utilizes a common voltage for generation and distribution.

What are its disadvantages?

1. *Excessive short circuit current levels* — With large blocks of power generated and distributed at low voltage, i.e. 6900 volts is considered low for such a block of power, the system short circuit level would have been exceedingly high and above the rating of available equipment. In order to keep the short circuit fault currents down to a reasonable value and allow the use of existing breakers of 500,000 kva interrupting rating, it was necessary to sectionalize the system and use reactors, and even then all breakers could not be closed.

2. *Inflexibility of system operation* — Because of the necessity of sectionalizing the system with reactors, the loading per bus section was limited, thus requiring careful load planning and supervision.

"Open" loops to a bus section meant complicated switching and operating practice in order to keep power available at all times when some sections of a loop were open.

Such a scheme also imposed limits on power — i.e. kilowatt — transfer from one section to another. The control of system reactive current, or kilovars as it is now called, is even more complicated. In all likelihood, it would have been impossible to obtain a reasonable

control of kilovars over the distribution channels without some additional control equipment.

3. *Difficulty of expansion* — Each time a new generator was added, the magnitude of the short circuit current would have increased, which would have had a material effect on *every* power breaker on the system. Hence, care must have been exercised to see that breaker interrupting ratings were not exceeded.

## SECOND SOLUTION

Because of the high short-circuit current levels, inflexibility, higher cost, and other disadvantages of further expanding the 6900 volt generation and distribution system, it was decided, after considerable study, to use 22 kv transmission with generators supplying power to the 22 kv system through step-up transformers. At the load areas, step down transformers were used to transform the power from 22 kv to utilization the voltage, 6900 volts. This system is shown in Figure 2.

The first impression of this arrangement, compared with the previous diagram of the 6900 volt system, is its simplicity, and it is simple and easy to operate, even though it involved the generation and distribution of more than 150,000 kw.

Twenty-two kv and not 33, 44, or even 69 kv was selected for the main distribution system, because 22 kv was high enough to adequately and economically handle the large block of power and yet fulfill the company's requirements for totally metal enclosed, phase segregated, unit type switching equipment.

It should be noted that this system consisted of separate integral units which were interconnected by a 22 kv transmission system. In the power house, the turbine-generator, step-up transformer, and one group of 22 kv metal-clad switchgear were one unit. At the step-down substations, the primary 22 kv metal-clad switchgear and the transformers, and in some cases secondary switchgear, were also a unit. These units could be added when desired, and at any location in the system without interfering with previously installed units. The ultimate system was laid out so that any one section of the system could be dropped without loss of power at any load bus.

Some of the features of the 22 kv system were:

1. *Short-circuit current bottlenecks removed* — The ultimate 22 kv system could be installed without exceeding 1,500,000 kva short-circuit duty on the 22 kv system and 500,000 kva on the 6900 volt system. The 22 kv system was tied solidly together without reactors.

2. *Simple in operation* — Since all breakers can be normally closed, any section could be switched in and out of service as required. This advantage alone was of extreme operating importance as loads could be transferred without any major scheduling requirements between mill and power house operators.

Excellent service reliability was available since a fault in any portion of a loop would be quickly isolated and the load area served over another channel.

Since all generator bus sections were tied together, maximum advantage could be taken of load diversity. Power could be easily transferred from one bus section to another for maximum economy and operating flexibility among the turbogenerator units.

The control of reactive current, or kilovars, was simply and automatically taken care of by the generator voltage regulator. Once the regulators were adjusted no further attention was required since the impedance between generating stations was constant. Since all of the 22 kv breakers on the distribution system were normally closed, there would be no great problem of kilovar control.

3. *Flexibility in operation* — Any generator unit, 22 kv bus, or any 22 kv line could be isolated for maintenance without disrupting service anywhere in the plant.

4. *Adaptability for changes in load* — One of the most important features of this system was that it could be expanded to the limits given without exceeding the interrupting rating (500,000 kva) of the breakers at the utilization points. New loads or new generating capacity could be added at any point without making previously installed equipment, 22 kv breakers, or substations inadequate, by merely extending the high-voltage loop.

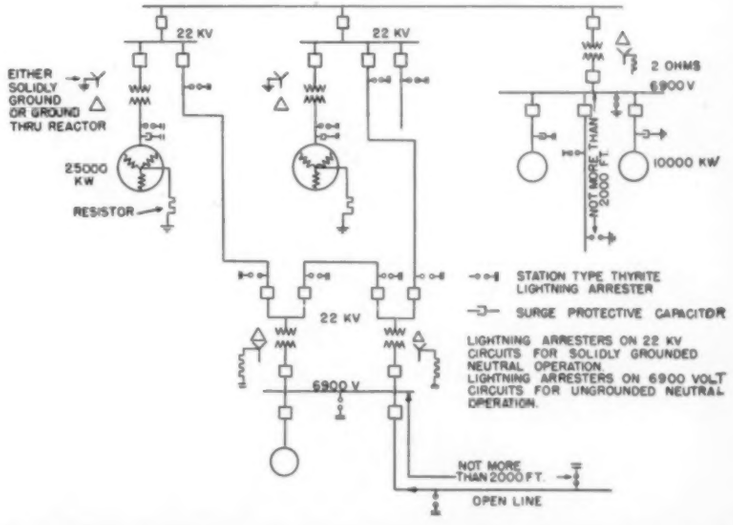
5. *Investment is less* — Overall system investment was 5 to 10 per cent less than for the 6900 volt system. The substations cost more in the 22 kv system, but this was more than offset by savings in transmission lines and switchgear.

Some of the other factors of this project are:

1. *Turbine generator voltage rating* — The turbine generator voltage rating could be selected at will, for each generator was connected to a step-up transformer which was connected to the 22 kv bus. Although any generator voltage could be used, 13,800 volts was a logical selection for a generator of this rating.

2. *Size of step-down transformer stations* — In order to keep the total short-circuit current on the 6900 volt utilization buses within 500,000 kva, it was desirable to limit the total transformer capacity per bus section to about 30,000 kva. Some of the loads, however, were not large enough to justify 30,000 kva transformers. As a matter of fact, they could justify transformers of

**Figure 3 — Grounding and over-voltage protection for 22 kv system.**


22 KV
22 KV
EITHER SOLIDLY GROUND OR GROUND THRU REACTOR
25000 KW RESISTOR
2 OHMS
6900 V
NOT MORE THAN 2000 FT.
10000 KW
STATION TYPE THYRITE LIGHTNING ARRESTER
SURGE PROTECTIVE CAPACITOR
LIGHTNING ARRESTERS ON 22 KV CIRCUITS FOR SOLIDLY GROUNDED NEUTRAL OPERATION
LIGHTNING ARRESTERS ON 6900 VOLT CIRCUITS FOR UNGROUNDED NEUTRAL OPERATION.
22 KV
6900 V
NOT MORE THAN 2000 FT.
OPEN LINE

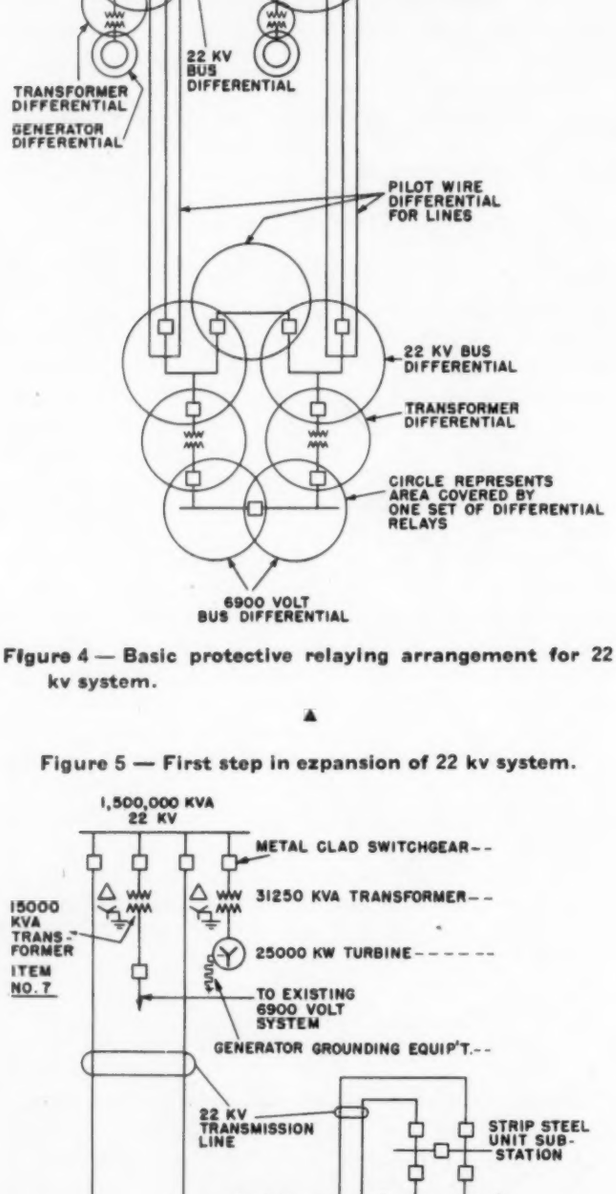

SYN. BUS DIFFERENTIAL
22 KV BUS DIFFERENTIAL
TRANSFORMER DIFFERENTIAL
GENERATOR DIFFERENTIAL
PILOT WIRE DIFFERENTIAL FOR LINES
22 KV BUS DIFFERENTIAL
TRANSFORMER DIFFERENTIAL
CIRCLE REPRESENTS AREA COVERED BY ONE SET OF DIFFERENTIAL RELAYS
6900 VOLT BUS DIFFERENTIAL

**Figure 4 — Basic protective relaying arrangement for 22 kv system.**

▲

**Figure 5 — First step in expansion of 22 kv system.**

only about half that size. Therefore, 15,000 kva transformers were a good selection. This size transformer could be used singly for small loads and in pairs of two per bus section for the larger loads. If more than 30,000 kva was required at one location, two or more bus sections should then be installed, each with not more than two 15,000 kva transformers per section.

3. *Grounding and overvoltage protection* — The basic arrangement for lightning protection, rotating machine protection, and system grounding is shown in Figure 3. Each 31,250 kva generator was wye connected with the neutral grounded through a resistor. This ground connection was used to operate a relay to trip the breaker on the 22 kv side of the step-up transformer in the event of a line-to-ground failure in the generator. The step-up transformer was delta connected on the low side and wye connected, solidly grounded, on the high side. There is no necessity to limit the magnitude of the ground fault current on the 22 kv system so it could be solidly grounded, thus permitting the application of grounded neutral type arresters which offer better protection.

The *step-down* transformer would be delta connected on the 22 kv side and wye connected on the 6900 volt side with the neutral grounded through a resistor.

A solidly grounded 6900 volt system was not desirable because of the magnitude of current that could flow during a ground fault. Limiting the ground current reduced the burning and melting effects of ground faults in rotating machines, switchgear, cable, and metallic parts, such as cable sheath, in the ground return path.

All 22 kv overhead lines had station-type Thyrite lightning arresters. The exposed overhead 6900 volt distribution circuits also had lightning arresters. All generators and the important 6900 volt motors had standard rotating machine protective equipment of arresters and surge capacitors.

4. *Relaying* — Figure 4 shows the basic protective relaying arrangement and illustrates how differential type relaying was used throughout, with pilot wire differential relaying for the 22 kv distribution system. Since the operation of a differential relay depends upon a "difference" in current, the relay can be set independent of the magnitude of load current and was fast in operation. The "directional" type of relaying could be used but it had the limitation of time and current grading and therefore would be relatively slow in operation. Furthermore, since the setting of a directional relay is dependent upon actual circuit currents, the relays must function with minimum expected system generation and yet be selective with maximum system generation.

5. *Step-by-step installation* — One of the outstanding advantages of the 22 kv system was that it was made up of integral units, the generator, transformer, and some of the power house switchgear forming a unit. The step-down unit substations were of a standard size and each was a unit in itself. The unit arrangement permitted step-by-step expansion in such a manner that previously installed equipment need not be affected. Each step was an entity in itself, yet each step fit into the system plan.

(*Please turn to page 101*)

# INDUSTRIAL *Grease Application*

***. . . . heavy industry, in general, owes much to the automotive industry on application of greases . . . . however, even though the making of greases themselves is in an advanced state of refinement, grease application methods are often far behind the times . . . .***

*by John R. LeVally,* VICE PRESIDENT

LINCOLN ENGINEERING COMPANY OF ILLINOIS

CHICAGO, ILLINOIS

▲ THE science of industrial lubrication, from the standpoint of the lubricants themselves, has received the attention of the best engineers and chemists in the petroleum industry for years, but the application of these lubricants, particularly the solid and semi-solid greases, and the equipment to apply them to the bearings, has been largely developed within the last fifteen years.

The problem of "greasing" automotive vehicles is largely responsible for most of the basic developments and improvements in equipment for the transfer of greases from refinery containers directly to bearings under pressure, and modified types of this equipment, originally designed for the "grease rack" of a service station or car dealer, built for heavy duty and large capacities, are now making the lubrication of industrial machinery easier, cleaner, and more positive, with a marked saving in maintenance, outage, and cost of lubrication.

The development of lubrication equipment in the automotive field took place more rapidly than in the industrial field very probably due to the direct profit motive involved. The "greasing" of a car or truck is not only a direct source of income to the owner of a service station or car dealer, but the lubrication department is also a main "feeder" source for other income producing services. This direct income, and profit motive put the necessary push behind the development and improvement of equipment to do the job faster, cleaner, and more efficiently.

Lubrication in the industrial field has always been considered an item of overhead or expense instead of a direct profit item, and as such the men responsible for improvements in methods and equipment have not always been able to gain the ear of management for necessary appropriations, and modernization has often lagged.

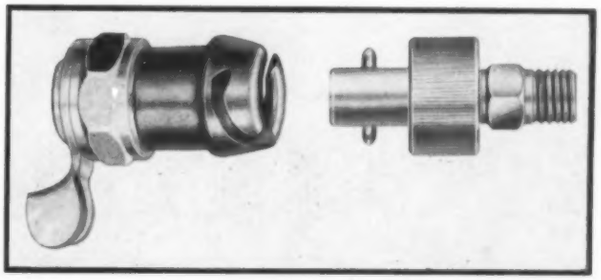
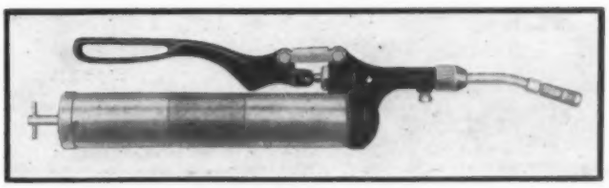


**Figure 1 — Familiar "pin type" fitting and coupler used to apply grease.**

▲

**Figure 2 — Lever operated grease gun.**



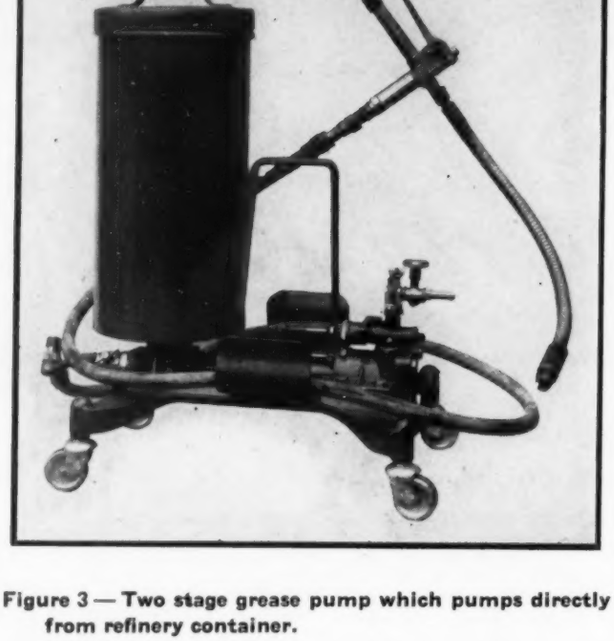


**Figure 3 — Two stage grease pump which pumps directly from refinery container.**

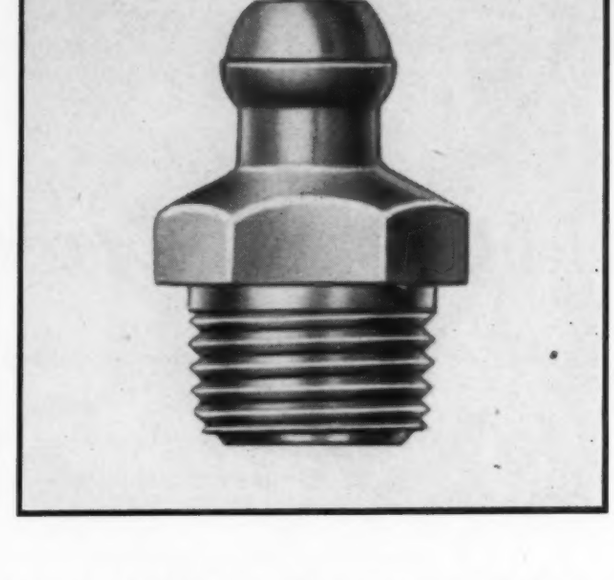


**Figure 5 — Standard hydraulic fitting used by U. S. Army.**

The first development in grease lubrication under pressure was of course the invention of the pressure fitting for the bearing, and the matching coupler (see Figure 1), which permitted grease to be pumped into a bearing under pressure from a hand pump. In the automotive field, the familiar "pin type" fitting was first introduced during and immediately after World War I, with lever-operated and push type hand pumps or guns and pin type couplers used to pump the grease into the bearings, through the fittings (see Figure 2). About this same time, mine cars were first lubricated by a similar method through a "flush type" fitting.

This method of applying grease to a bearing under pressure, by hand pumping through a fitting, rapidly gained favor in tbe automotive field, replacing the old grease cup on all automotive vehicles, and pressure lubrication fittings soon became standard equipment on all automobiles and trucks.

**Figure 4 — Barrel pump used for oils and liquid products at medium or low pressures where large volumes are required in fixed quantities.**

While this idea did not take on so quickly in the industrial field, peculiarly, the first power-operated grease pump was developed for the lubrication of mine cars, and at about the same time a high pressure, wire-wound, rubber hose was developed to carry the grease from the pump to the bearing under pressure.

This pump was a single acting piston type, operated by compressed air, and developed 20 times the air pressure, or approximately 2000 psi grease pressure with the usual 100 psi air pressure available.

Again the automotive industry, recognizing the value of a power-operated system of lubrication, adopted the power pump or compressor almost immediately, and while industry continued to apply grease lubrication by hand or by grease cups to a large extent, power lubrication under high pressure became the standard practice for all automotive vehicles.

For a number of years these air-operated grease pumps were made with capacities of 1 lb, 25 lb, and 75 lb, but all had a container that had to be filled, which meant transferring the grease from original containers to the pump container. This necessitated handling the grease, which is always a messy job, and also made it impossible to prevent some degree of contamination with dirt, dust, etc. In 1931, after years of experiment, a two-stage grease pump (see Figure 3) was developed that would pump the grease directly from the original grease container received from the refinery, through a hose, valve, coupler and fitting into the bearing. This was probably the most important development made in this field after the original power pump, as it enabled the operator to put grease directly into the bearings from the original refinery containers without handling or exposure to contamination.

Improvements came rapidly after the development

of this first "barrel pump," and designs were perfected with refinements in pumping mechanisms, foot valves, etc., so that today pumps are available that will not only pump all kinds of greases, from the lightest to the heaviest viscous and fibrous types, from original drums and deliver under high pressure through pipe lines, hoses, etc., but will also pump such other materials as mastics, putties, deadening compounds, sealing compounds, rubber cement, etc., from original containers.

At the same time that these high pressure pumps were being developed, similar types of barrel pumps were developed to handle oils, gear lubricants, and liquid products at medium or low pressures, for use on assembly lines, etc., where large volumes were required in fixed quantities. Such a pump is illustrated in Figure 4.

Along with the advent of the barrel pump, improvements were made in the types of fittings and couplers used to apply the grease to the bearing, such as the button head, Dot, Zerk and hydraulic types. Automotive vehicles followed a standardization program and with each improvement the whole industry adopted it, thus preventing confusion. This was not done in industry, with the result that even today there is no set standard as to type of lubrication fitting a machine may come equipped with, and a plant often finds its equipment fitted with several different types of lubrication fittings.

In 1942, the Ordnance Department of the U. S. Army received equipment made by practically every manufacturer in the country, and since there was no standardization of the type of lubrication fittings used, single pieces of equipment would have three different types of fittings on them, where sub-assemblies were supplied by different contractors. This caused confusion in the field, and necessitated that each vehicle have a multiplicity of nozzles and attachments for their grease guns to fit all three types of fittings. The Ordnance Department called on the manufacturers to design a fitting for universal use that would pass the volume of grease of the button head type, and could be contacted with the hydraulic type nozzle, which was more generally used. This resulted in the development of the "Bullneck" hydraulic type fitting, known as Ordnance Standard CLDX6A, which is now standard for all types of equipment built for the Army. It is shown in Figure 5.

This standardization might well be followed by industrial designers and engineers in the use of lubrication fittings, as the present practice seems to be to use whatever type of fitting they happen to think of, or used on the first machine they built.

The one purely industrial development in equipment for lubrication with grease is the so-called "centralized" system, in which the grease pump feeds grease to the bearings under pressure through measuring valves, or injectors. With these injectors, a predetermined, measured amount of lubricant can be pumped into the bearing, and with proper automatic controls, this measured amount can be fed at regular, timed intervals. Two types of centralized systems are in use for this purpose; one using a dual feed line from the pump to the bearing through the injector, in which the effect is obtained by reversing the direction of flow in the feed line, and the other using only one feed line from pump

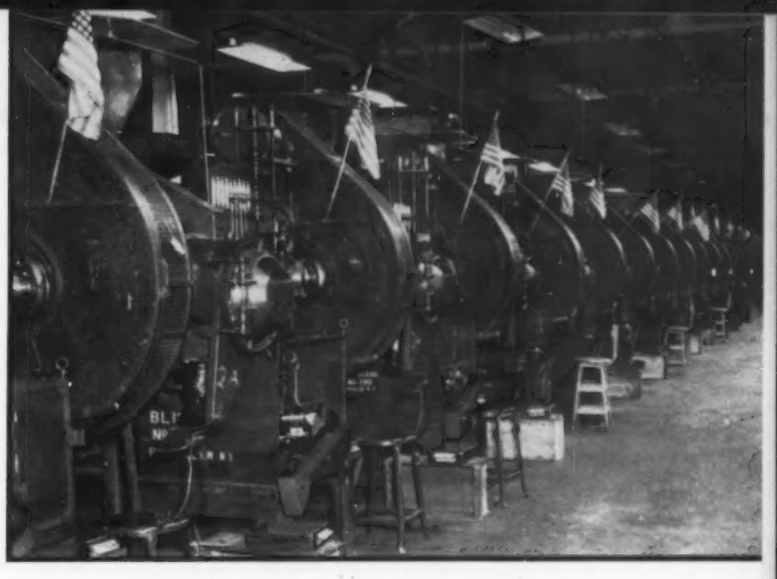


**Figure 6 — Battery of machines lubricated by a centralized system.**

to injector, in which the effect is obtained by releasing the feed line pressure between cycles. Both of these systems can use the barrel type pump to advantage, pumping the grease from original containers into the system, either air or electrically operated.

Oil companies have made the finest greases available for every purpose and condition, but all too often they find the machine or plant they are servicing inadequately equipped to handle and apply the grease they recommend. This forces furnishing a grease, not from the sole standpoint of what is best for the bearing condition, but which is also limited by the ability of the equipment, or lack of equipment to handle the proper grease.

Good grease, properly applied, is still cheaper than new bearings, and in the high production period of World War II this fact has been brought home forcibly to industrial management, with the result that more thought and action has been put behind providing adequate equipment for properly applying greases. A good start has been made, but all too many plants are still using obsolete, hand methods of applying greases to bearings at long intervals and in hit-or-miss quantities, when equipment is available to put the proper grease, in proper quantity, at proper intervals, into the bearings, or on bearing surfaces.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# Blast Furnace Operation

## UNDER ELEVATED TOP PRESSURE

*. . . . recounting the troubles and results of operating a blast furnace with elevated top pressure . . . . such operation will show definite advantages when mechanical difficulties are overcome . . . .*

*by Frank Janecek*

BLAST FURNACE ENGINEER

REPUBLIC STEEL CORPORATION

CLEVELAND, OHIO

▲ ALTHOUGH blast furnace operation under elevated pressure has to date shown some encouraging results, consistent results have not been obtained because of various delays encountered during the experiment. Some were directly due to elevated pressure operations, other delays were ordinary run-of-mine, with no connection with elevated top pressure and still others were the result of the times. In the following discussion the favorable as well as unfavorable aspects will be related, but first let us consider the lines of the furnace and the changes made to the equipment to make pressure operation possible.

The furnace has a 27 ft hearth, 30 ft bosh, and 20 ft stockline. It is 107 ft 8½ in. from the iron notch to tunnel ring. The volume is 46,230 cu ft from the centerline of tuyeres to the closed bell. It is equipped with 18 tuyeres and a 15 ft diameter bell. Thus, the ratio of stockline area to bell area is 1.78, and the ratio of bosh area to hearth area is 1.23, while stockline area is 54.8 per cent of hearth area. The furnace volume above the tuyeres is 80.7 cu ft for each sq ft of hearth. The bosh angle is 83°-17′-32″.

In preparing for the elevated pressure operation, changes above the furnace charging platform consisted of adding two gas lines from the uptakes to introduce the furnace pressure on top of the bell. A third line vented this pressure to the atmosphere (Figure 2). Valves in these lines are automatically opened and closed by air cylinders, just before the large bell dump. To prevent over-stressing the three roller bearings that hold the distributor down, counterweights were added to the revolving hopper to compensate for the higher pressure under the small bell. To minimize gas leakage around the stockrod, its diameter was reduced to one inch, and a protecting tube carried to the top of the structure. A close clearance at this point prevents leakage from being serious. These were the only changes made above the charging floor.

It is important to note the bleeders, of which there are two of the bell type, with gas pressure keeping the bleeders tightly closed. The bleeders are connected by cable to a motor-operated winch. Pressure switches actuate the motors and pull the bleeders open when the furnace slips or rolls. This type of construction is very important; the ordinary cap type of bleeder is not adequate.

It was thought that emptying the dustcatcher under elevated pressure would present a problem, and that a bed of flue dust would have to be left at all times in the dustcatcher to act as a seal. However, no trouble was experienced in keeping the dustcatcher dry.

Since the restricting device is in the gas line after the gas washer, special consideration had to be given to getting the water out of the gas washer under the

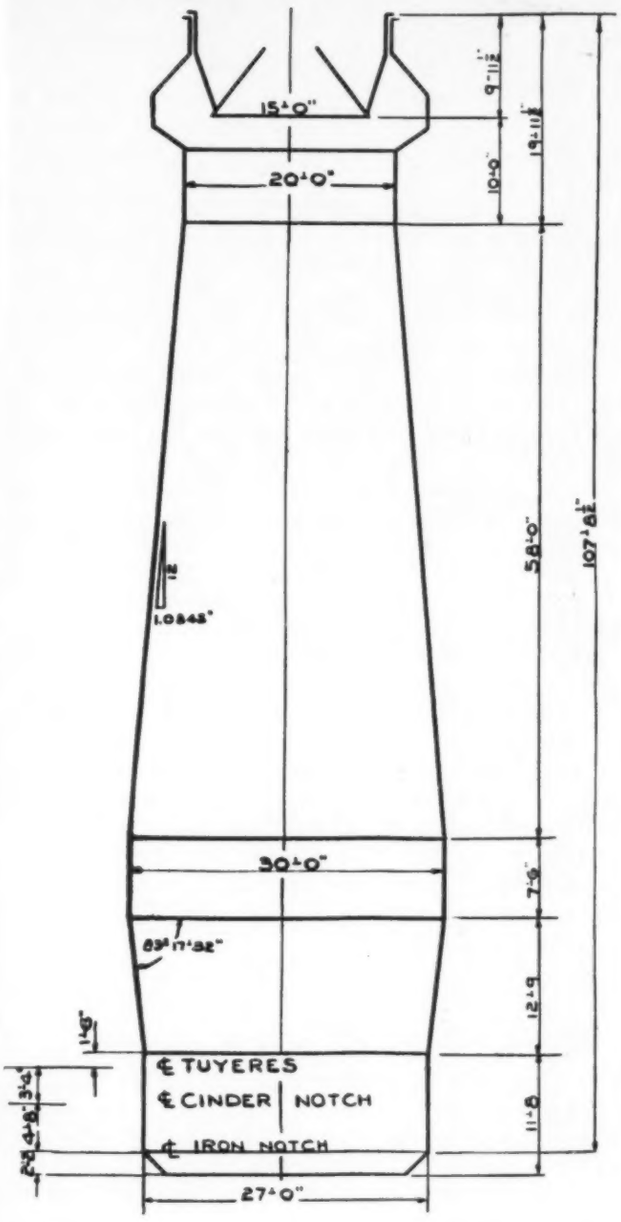



**Figure 1 — Section through blast furnace operated under elevated top pressure. Area of bell is 176.6, stockline is 314.1, straight section is 707.1, and hearth is 572.5 sq ft. The ratio of the stockline area to bell area is 1.78, the ratio of the stockline area to the hearth area is 0.548 and the ratio of the straight section area to the hearth area is 1.23. The volume works out to 80.7 cu ft per sq ft of hearth area.**

elevated pressure. This was accomplished by introducing a butterfly valve in the water discharge line (Figure 3). This valve is automatically regulated by a float control. The level of the water in the bottom of the gas washer thus opens or closes the butterfly valve in the water discharge. This control installation has worked exceedingly well, and has been practically trouble proof.

The restricting valve actually controlling and maintaining the 10 lb pressure in the gas washer, dustcatcher, downcomers and furnace top was constructed of three 30 in. butterfly valves, and in addition, three 12 in. through pipes controlled by solid plate discs were placed in the line (Figure 4). This construction was dictated by the desire to offer as little restriction as possible to the gas when operating for a test period without elevated top pressure. It also permitted good control when gradually increasing top pressure in half-pound steps. Two of the 30 in. butterfly valves are hand operated and the third is automatically controlled.

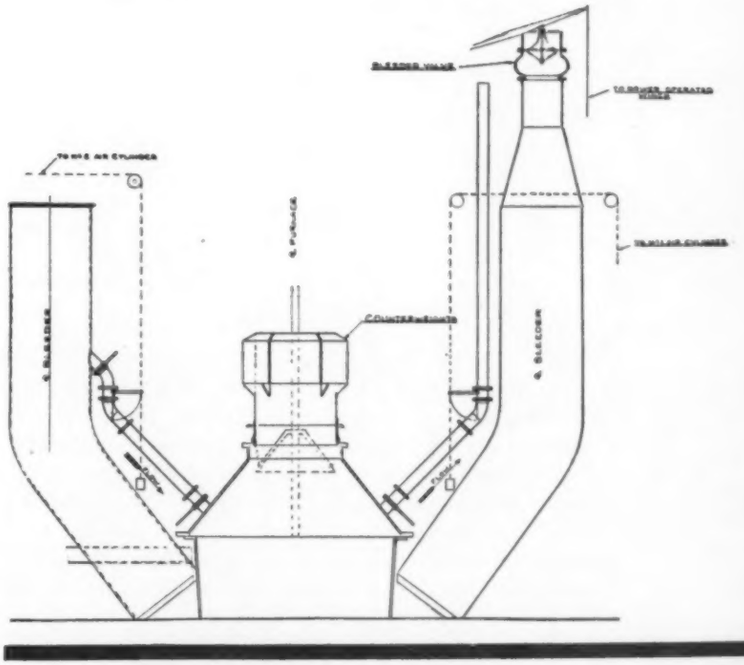
The furnace is supplied air by a turbo blower with a capacity of 90,000 cfm at 30 psi gauge. It was necessary to anticipate that more than 90,000 cfm would be required and at more than 30 psi. Therefore, an identical spare blowing unit was interconnected to act as a first-stage compressor and discharge into the suction of the second unit through an intercooler. This is an expensive means of obtaining blast air, but was the only method available since the turbo blowers were at that time in process of manufacture.

Operation on usual top pressure was started in November, 1943. However, many delays due to manpower and equipment were encountered and it was not until January that data of any value were assembled. Even then aggravating delays upset a truly representative run, and it was March before the performance settled down to a reasonable semblance of a blast furnace operation.

Figure 5 shows the production curve for the entire month of March, when production averaged 1293 tons per day. However, during the first 15 days, when a reasonably steady operation was maintained, the daily tonnage stood at 1324 tons. The quality was fair, but sulphur averaged above .040 on three days.

Figure 5 also shows coke rate, as charged and also reduced to a dry basis. The average for the month was

**Figure 2 — Sketch of top of blast furnace operated under elevated top pressure, showing arrangement of pressure equalizing lines.**



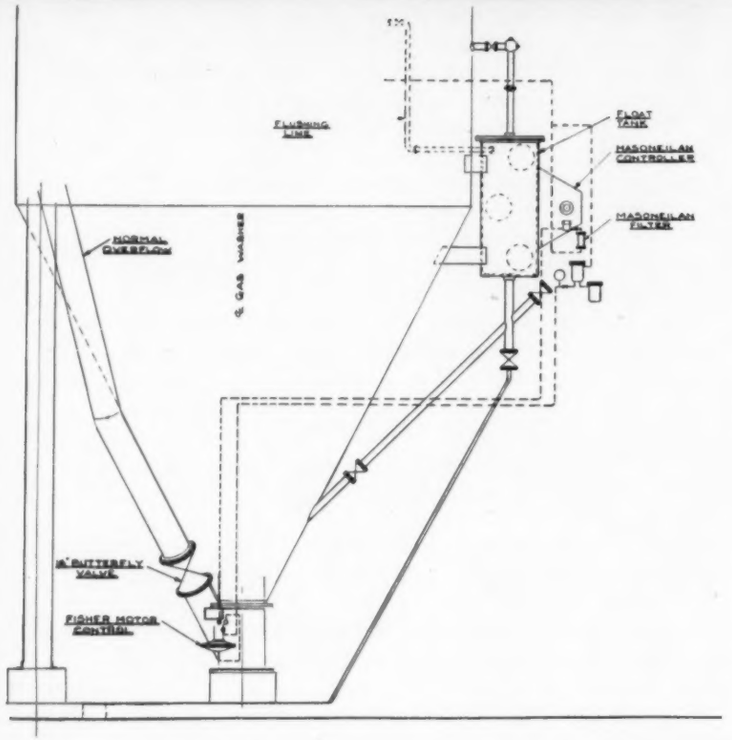
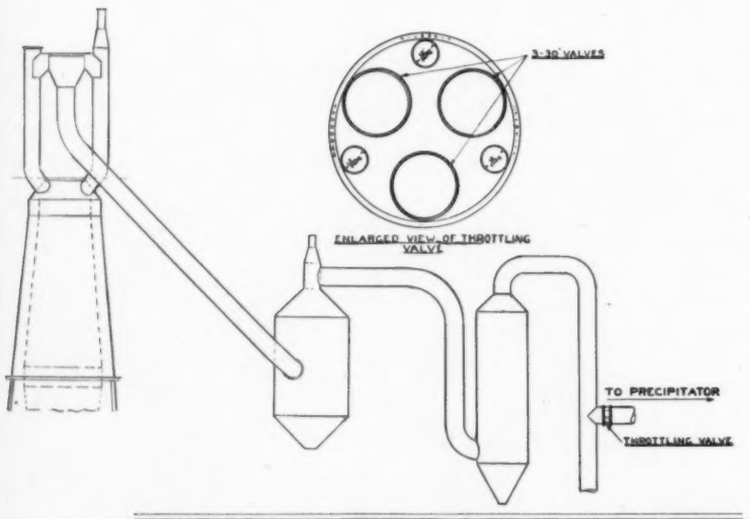



**Figure 3 — A butterfly valve was introduced in the water discharge line from the gas washer, and operated by float control to regulate water level in the bottom of the washer.**

▲

**Figure 4 — Sketch showing details and location of throttling valve used to set up and maintain the high gas pressure.**




1898 pounds as charged and 1702 dry. The first 15 days, however, showed a dry coke rate of 1680. Radical swings in moisture in the coke are no doubt responsible for the loss of tonnage and also for the days when quality fell off. Variation in coke moisture was from 8.8 to 14.5 per cent. It should be mentioned that the coke quality varied considerably, with coke at times being produced from a great many kinds of coal. Coke as charged included everything over a $\frac{5}{8}$ in. screen. All coke charged was weighed.

Lost time is also shown in Figure 5. The solid line indicates total lost time. Lost time is defined as the actual time the turbo blower is down, and also the time that a first or second check is being blown. However, from a wind consumption standpoint the furnace is credited with using 30,000 cu ft for each minute of a first check and none while a second check is blown. This averaged 110 minutes per day for the period under consideration.

Under the solid lost time line is a dotted curve which represents actual time lost due to casting. The average for the 15 days is 56, or about 11 minutes per cast. The roughness of the operation can be judged by the difference between 110 and 56, or 54 minutes lost each day due to other causes.

The wind volume curve shows that trouble was experienced in maintaining 85,000 cfm, and a glance at the pressure curve indicates a rise even with lower wind volume.

It should be noted that the hot blast temperature averaged only 886 F. The furnace would not handle any greater temperature.

From the humidity curve it must be noted that at no time did the natural air even approach a 3 grain level, with an average of 1.84 for the period.

Daily steam consumption, corrected to 27 in. vacuum and 60 F intake air averaged about 1,500,000 lb per day. The steam used to compress each 1000 cu ft of air averaged 13.5 lb.

Top pressure remained reasonably constant at $1\frac{1}{2}$ pounds. The top temperature chart has no value, since the quantity of water added to each charge was not measured.

Therefore, the pertinent figures from this March chart would be:

1324 tons of iron per day.
1680 lb of coke per ton of iron.
886 F hot blast temperature.
110 minutes daily lost time.

This, then, is the best which had been obtained up to that time under the usual operation of low top pressure. Dust losses were high, averaging 268 lb per ton. Scrap was not used in the burden, although 492,858 lb of sinter were used in a total charge of 5,397,391 lb per day.

During the month of April, the following average figures were obtained:

1,243 tons of iron per day.
80,270 cfm blast volume.
1,716 lb of coke (dry basis) per ton of iron.
241 lb of flue dust per ton of iron.

By April 26, all of the necessary material for elevated top pressure operation was installed, and the restricting valve was partially closed to increase the back pressure $\frac{1}{2}$ psi. Each day thereafter, an additional $\frac{1}{2}$ psi was added until 10 psi was reached.

When 5 psi top pressure was reached, dust production took a remarkable, sharp drop. Low dust production continued throughout the experiment, with what was considered normal wind volume, 85,000 cfm.

The data for May (Figure 6) indicate the gradual increase of top pressure until 10 psi was reached on May 9. The daily steam consumption and rate per 1000 cu ft reflect the increased pressures. With a 4 lb rise in top pressure, blast pressure rose from 24 to 27, or 3 psi.

During this period, the average production for the 15 days is only 1285 tons per day, 29 tons less than the previously considered period in March. However, the coke rate was down 19 lb, with total lost time reduced from 110 to 99 minutes a day. It must be noted that the casting delays increased from 56 to 71 min per day, or 3 min per cast.

It is also worthy of note that the wind volume was held constant and blast pressure varied only 2 psi, once the maximum top pressure was reached. It was possible to raise the blast temperature to an average of 1109 F. The average humidity also increased to 4.51.

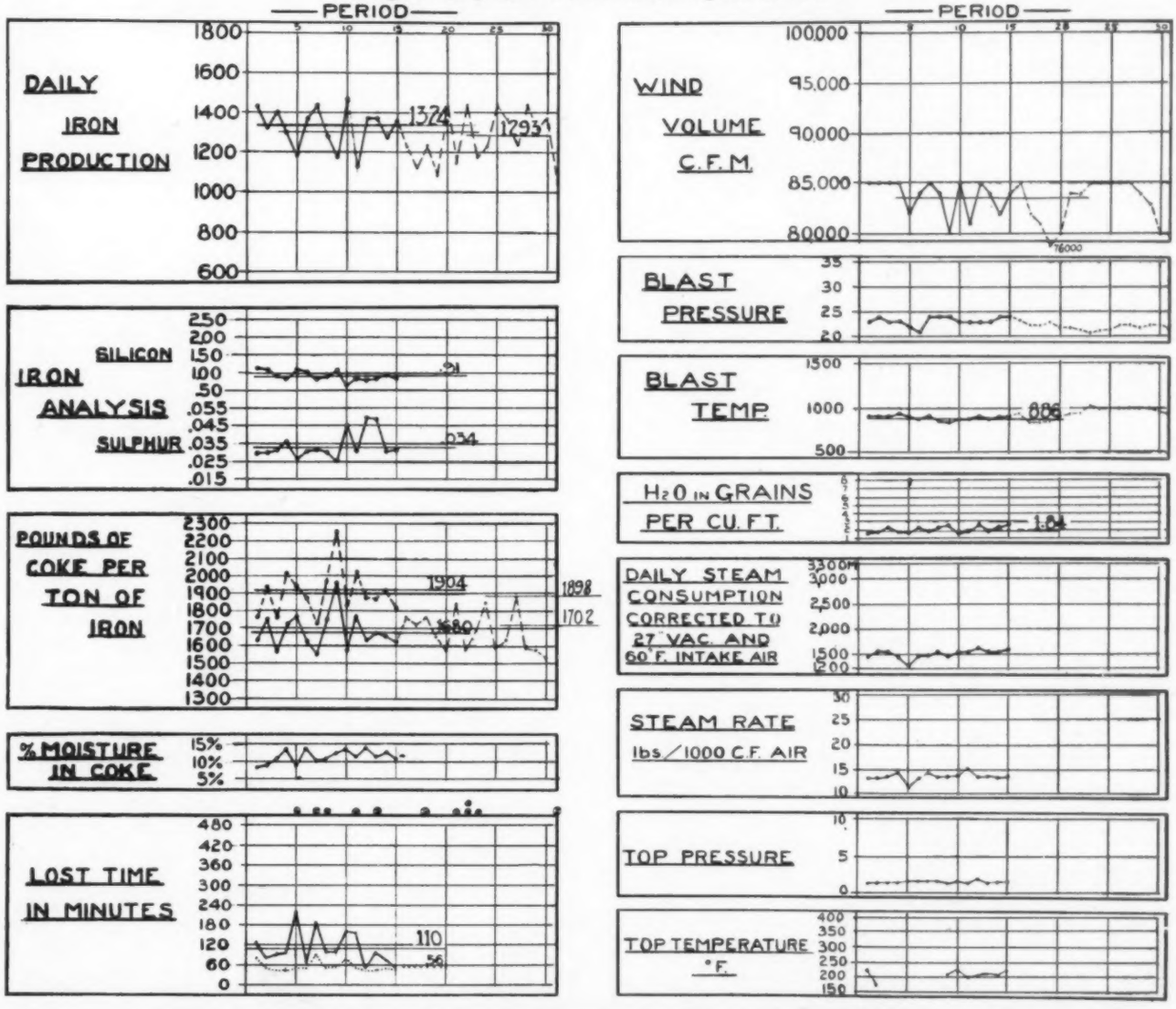
During this period the efficiency of the operation increased. No sinter was charged. 4,711,426 lb of ore charged daily produced only 29 tons less than the previously considered period, when 5,397,391 lb were used. In other words, 343 tons less burden made only 29 tons less iron. Flue dust for the month was only 84 lb per ton.

More can be learned from a longer period of operation on 85,000 cfm. However, the furnace did behave itself, it refused to slip and roll and had indications of wanting to accept even more heat and burden. This was gradually being explored when, on May 18, while back-drafting during a tuyere change and just before going back on the line, an explosion destroyed the brick stove stack. In about 9 hr the furnace was put back on the line and the available heat in the stoves was soon exhausted. The burden was cut from 2.14 to 1.64, followed by a further reduction to 1.44 the next day. On the 22nd, the wind was cut to 70,000 and the burden to 1.29. On the 23rd the burden was increased to 1.44.

On May 24th some slight relief was had by using one stove as a stack for either of the others which were on gas, the burden was further increased to 1.74 and the wind to 75,000 cfm. One chimney valve was removed from each of two stoves and the openings in the stoves were blanked, then temporary stub stacks were erected on the stack flue, and on the 25th, full wind of 85,000 cfm was on the furnace again. The following day 950F hot blast was maintained.

It had been planned to operate a month on 85,000 cfm but of course that was shattered on the 18th. A furnace must have hot blast; even 700 F does miracles, we discovered.

**Figure 5 — Charts showing operation of blast furnace during month of March 1944. The data for most curves are given only for the first fifteen days of March.**



The delays in June were discouraging, but the following averages were held:

1,278 tons of iron per day.
89,730 cfm blast volume.
1,735 lb of coke (dry basis) per ton of iron.
283 lb of flue dust per ton of iron.

However, we looked forward to July and hoped the black cat had gone its way. Our hopes were soon dashed for it may be noted from Figure 7 that the total delays for each of the first 10 days reached 211 minutes per day. Casting delays remained reasonably low at 64 minutes. After the 15th of the month the delays dropped sharply and it appeared for a while we might have a decent run, but on the 27th the goggle valve after the dustcatcher was leaking badly, as was the cap bleeder on the dustcatcher, and it was necessary to take a shut-down.

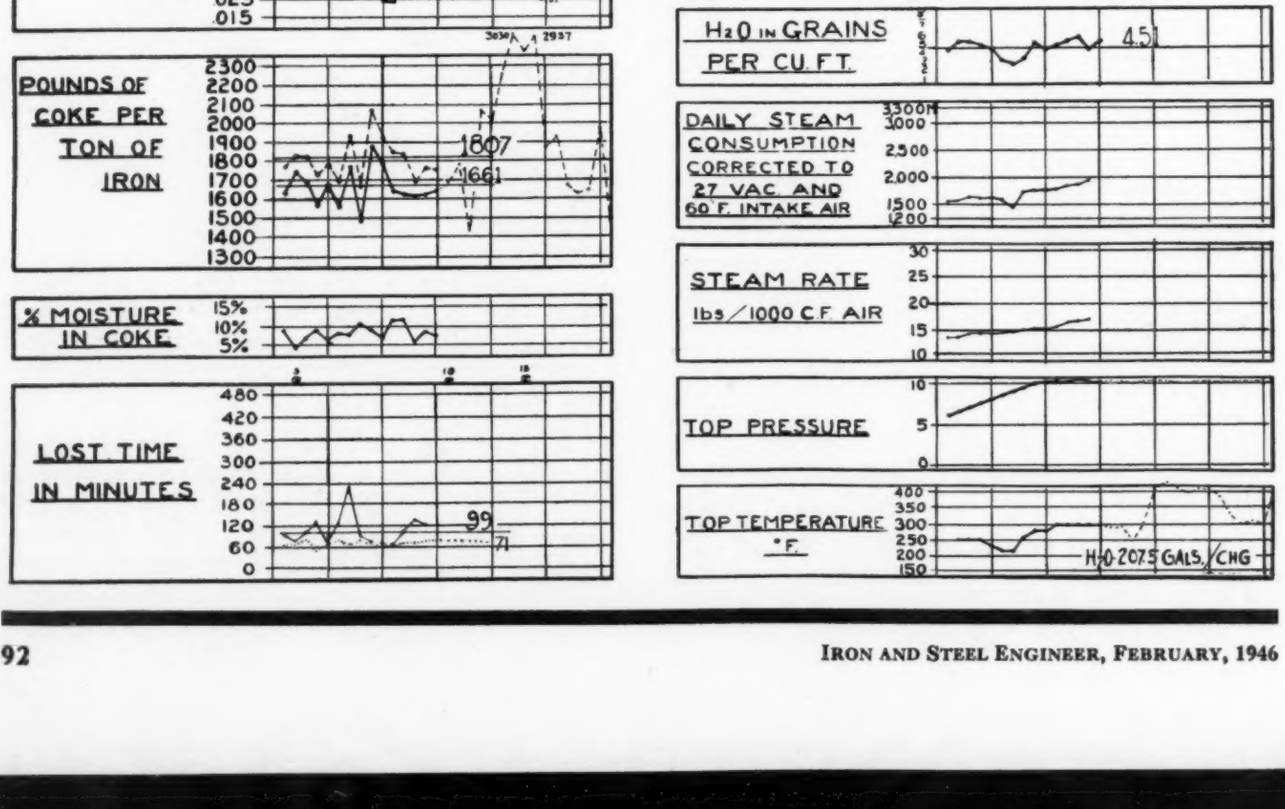
It should be particularly noted that from the 15th through the 19th 95,000 cfm wind was maintained. The tonnage produced did not keep up with the wind increase. It was then decided to further increase the wind 1000 cfm per day until 100,000 cfm was reached. On the 22nd, blowing 97,000 cfm, 1668 tons were produced on a dry coke rate of 1495 pounds. The wind was further increased until on the 25th 100,000 was being blown. This produced 1455 tons on a coke rate of 1561 pounds. The wind per pound of coke figures 54.5 cu ft. The next day 1773 tons were produced on a coke rate of 1389 pounds, with 54.6 cu ft of wind per pound of coke.

If we analyze the period from the 19th through the 27th, we find an average production of 1487 tons of iron per day, on a coke rate of 1634 lb per ton. The daily lost time was 121 minutes, or 2 hours and 1 minute out of every 24; 13 minutes were lost at each cast for a total of 66 per day. The silicon curve shows almost a straight line and sulphurs are within limits.

Now let us examine the wind picture. On the 19th, with 95,000 cfm, the blast pressure was 27 psi and rose to 29 psi when 100,000 cfm wind was reached. The third day of this high wind it rose to 31 psi. The blast temperature averaged 1078 F, again higher than the previous low pressure operation.

The steam consumption curve tells a sad story. On the 5th of the month the two turbo blowers were run in series and the pounds of steam per day jumped from

**Figure 6 — Charts showing operation of blast furnace for first fifteen days of May 1944. On May 18 an accident occurred which upset operations for the rest of the month.**



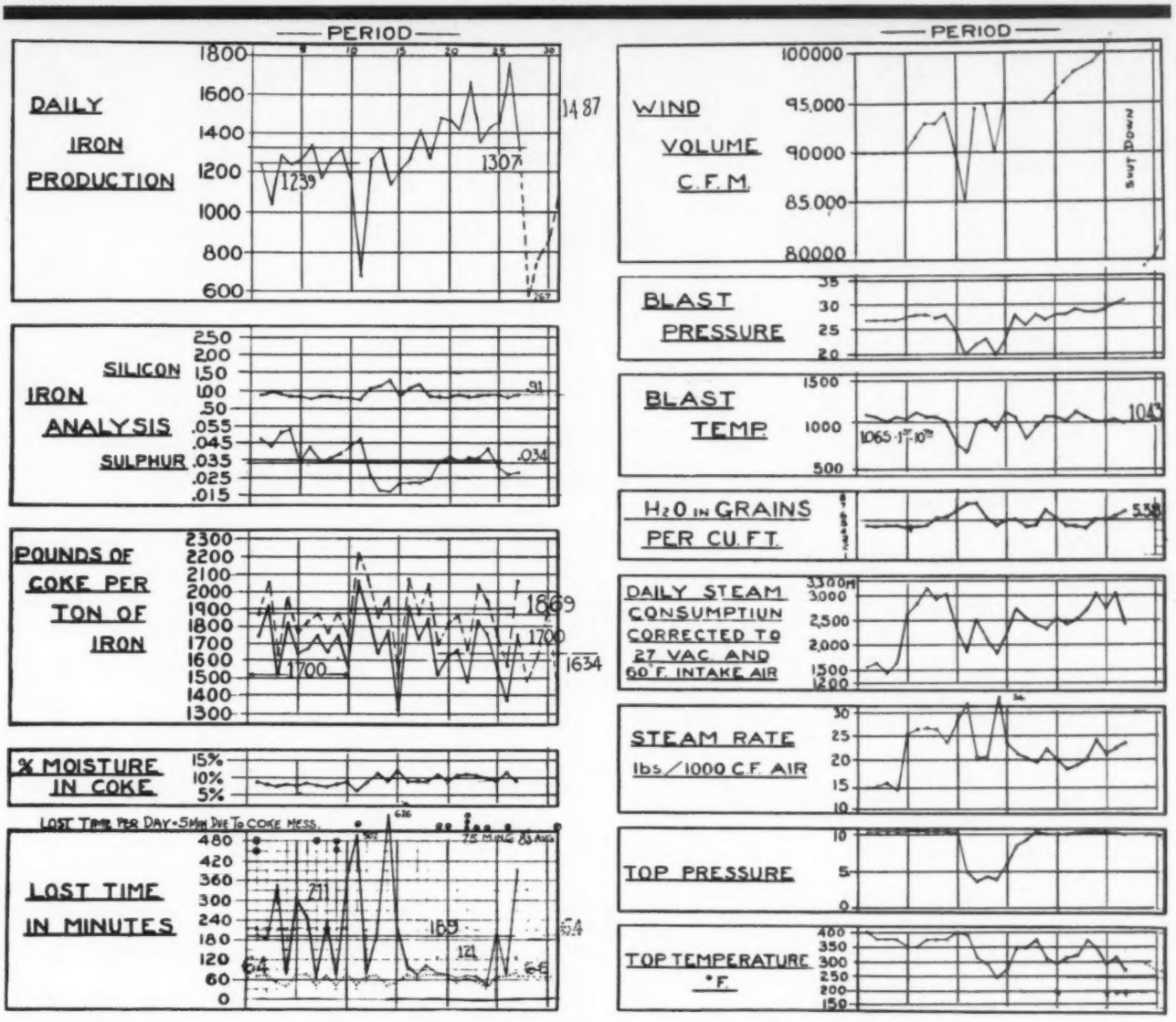



**Figure 7 — Charts showing operation of blast furnace from the 1st to the 28th of July, 1944, when the furnace had to be shut down temporarily due to gas leakage. The asterisks on the top temperature curve show when water was applied to the stock, 76.5, 21.75, 44.25, and 39.5 gallons per charge being used.**

1,620,000 to 2,620,000. A truer comparison can be drawn from the steam per 1000 cu ft of air which jumped from 14 to 25.1 lb. This of course would not have been the case if one turbo blower, built to operate at a high volume and pressure, had been available for this experiment.

The final point of interest on Figure 7 is the top temperature curve, which is low in the first part of the month without water on the stock, but even lower from the 19th on. The 20th, 25th, 26th, and 27th show small amounts of water being used, 76.5 gal per charge, being the maximum.

It should also be mentioned that 5,813,313 lb of ore were used to make 1487 tons of iron. Comparing this with the March figures we find an increase of 163 tons per day from an increase of 212 tons of additional ore charged into the furnace. Flue dust produced for the July period was 194 lb per ton of iron.

August operation is not very good when taken from a monthly viewpoint. Two shutdowns, one for 5½ days, were made necessary by a warped large bell hopper. The bell and hopper at the seat were cut and eroded by gas escaping past the seat. In view of this condition it was decided to operate on low top pressure and endeavor to check against the previous low pressure operation. We then have the period in August from the 19th to the 31st during which 1357 tons of iron were produced per day (Figure 8). Silicons were high coming off the bank. The coke rate dropped to 1615 lb per ton of iron, a new low. Total lost time at 98 minutes and casting delays at 51 minutes were lower than any previously recorded.

Blast temperature at 980 F was lower than the temperature carried on elevated pressure operation, though slightly higher than the March period. Steam rates verified those obtained in the March period.

Comparing this period with the March run, 5,453,492 lb or 2726 tons of burden were charged per day to produce 1357 tons of iron. This represents a daily increase in production of 23 tons of iron, obtained with only 28 additional tons of burden, a more efficient operation than March, but nevertheless almost as

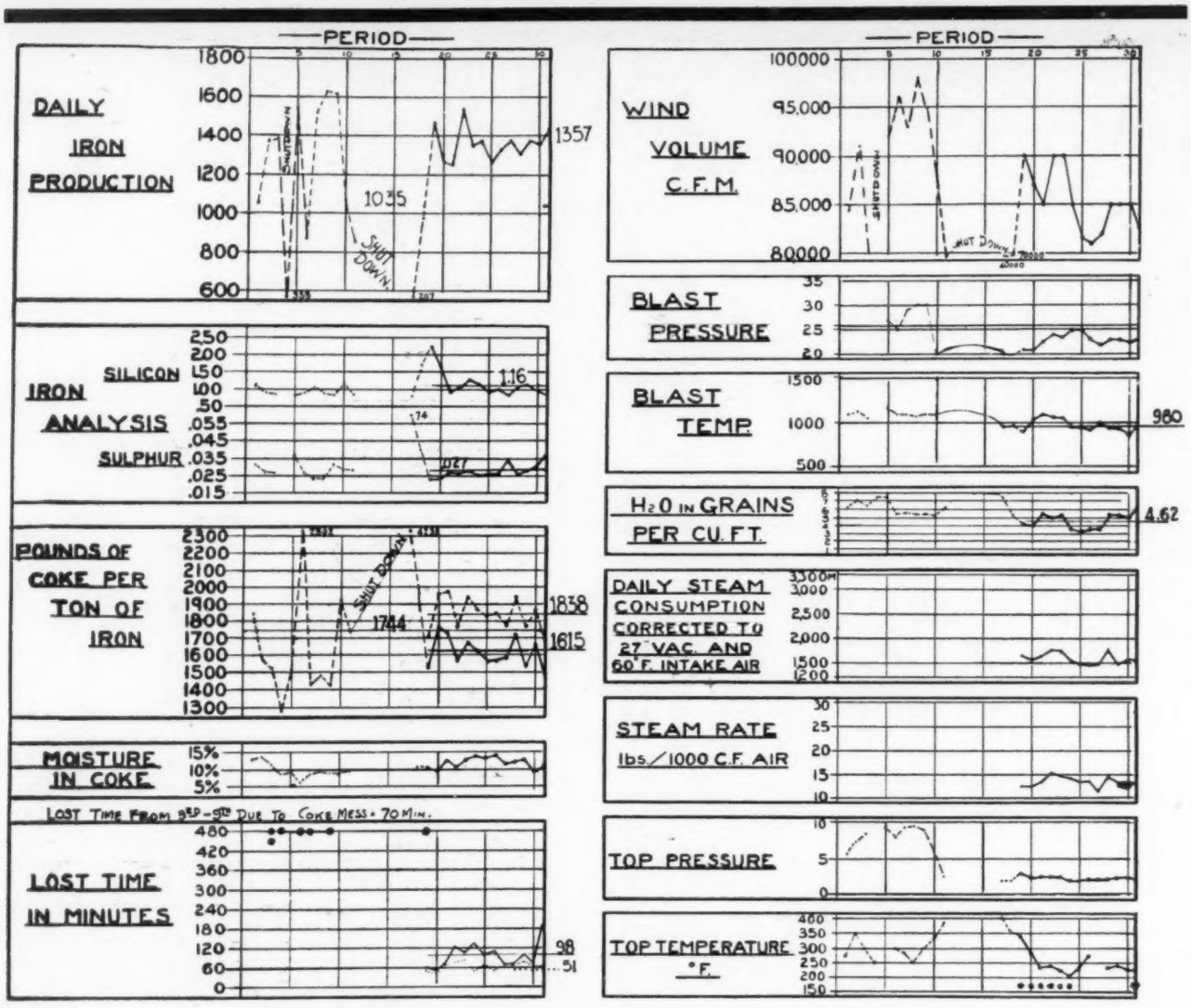



**Figure 8 — Charts showing operation of blast furnace during August 1944. Asterisks indicate water on stock with 345, 387, 378, 380, 357, 279 and 63 gallons per charge.**

erratic. Flue dust produced for the August period was 337 lb per ton of iron.

In summarizing this experiment to date, it is necessary to base impressions on very short periods of operation, with even those periods plagued with delays not found in normal times. In addition to delays already mentioned it might be of interest to relate some others. The cutting action of flue dust expelled through a small hole in the uptakes or downcomers, or through a poorly seated cap bleeder under 10 psi pressure compares favorably with the results produced by a scarfing torch on a billet. Any small opening soon was enlarged to proportions which required a shutdown. The restricting valve group was made up of commercially standard butterfly valves, which proved too light for the service and were responsible for delays. The equalizing valves proved inadequate and contributed their share to the delays. A burned pipe coil adjacent to the iron notch also contributed.

A leaking large bell and hopper prevented the space under the small bell from venting promptly, thus delaying the dump of the small bell and making for an aggravating operating condition. It definitely does take longer to cast the furnace under elevated pressure operation, and there is a greater tendency to make a coke mess.

From observation, the furnace operates much smoother under elevated pressure, moving steadily and having the ability to take more heat; top temperatures are lower, and on the same wind dust production will drop from 350 pounds to under 90, although as wind is increased to the point of equal gas velocities rising from the stock, flue dust production again rises but not as high as without elevated pressure.

It can be concluded that the process is metallurgically sound and gives promise of definitely proving itself when the mechanical obstacles are finally overcome and a period of operation of at least 60 days can be obtained. It is advantageous to operate with the reduced volume of gas resulting from operation at elevated pressure. The dustcatcher and gas washer are called on to handle smaller volumes for a given rate of blowing.

To date it has been a tantalizing experiment with enough bright spots to make it intriguing. Only when

(*Please turn to page 101*)

# Lighting Improvements

## FOR STEEL PLANTS

*. . . . although developments in plant illumination have not been revolutionary, improvements have been made in its application . . . . a new technique has been developed for the appraisal of lighting systems on a cost basis . . . .*

by D. H. Tuck, ELECTRICAL ENGINEER

HOLOPHANE COMPANY, INC.

NEW YORK, NEW YORK

▲ IN the lighting business there have been no revolutionary advances made during the war. Lamps are essentially the same as before the war — incandescent, mercury and fluorescent, and the lighting units are the same as before the war with some new types for special application.

Improvements in lighting are mainly in application and mechanical advantages. Studies have been made which have integrated all that we know about light and seeing so that personal likes and dislikes, prejudice, the effects of super-salesmanship, reciprocity, buying and false advertising will be side-tracked and the facts as shown by an intelligent analysis of the problem will govern the decisions.

This paper naturally divides into two parts: first a discussion of those fundamental concepts which have resulted in new engineering thinking and second, a discussion of specific improvements that have been made in equipment as a result of experience gained during the war.

In the rush of designing the gigantic additional manufacturing facilities for war time production, engineers were called into service who were not used to the slipshod methods of the lighting engineers. These men were accustomed to applying factors of safety to their calculations to allow for the many vicissitudes of actual use such as poor maintenance, poor voltage regulation, heat, cold, humidity, water, ice, dirt, dust and fumes, poorer grades of materials and substitute materials. They wanted to know what they could expect from the lighting in actual working conditions as compared with laboratory and factory tests and drafting room calculations. The result of these embarrassing questions has resulted in field data from which an "in service factor" can be approximated so that the drafting room calculations based on laboratory and factory tests can be multiplied by these factors and actual in service footcandles of illumination can be predicted within a practical degree of accuracy. In service illumination is that which can be measured on the work after six months of plant operation. It is found by multiplying the design illumination by the in service factor or by dividing the desired in service footcandles by the in service factor to find the design value of illumination.

The in service factor is made up of several different factors such as lamp aging, dust and dirt on lamp, reflecting or transmitting surface, lamps not burning, voltage drop, interception factor and atmospheric absorption. These individual factors will vary with type of lamps and equipment and varying conditions of service and the following tables will give their approximate values for steel mill conditions.

Presented before A. I. S. E. Philadelphia District Section Meeting, October 6, 1945.

### LAMP DEPRECIATION FACTORS

| Lamp size—watts | Factor |
|---|---|
| Incandescent lamps | |
| 200 | 0.88 |
| 300 | 0.87 |
| 500 | 0.85 |
| 750 | 0.87 |
| 1000 | 0.83 |
| 1500 | 0.71 |
| Mercury lamps | |
| 400 | 0.88 |
| Fluorescent lamps | |
| 40 | 0.84 |
| 100 | 0.79 |

### DUST AND DIRT DEPRECIATION FACTORS

| Condition | Factor: Incandescent | Factor: Mercury ① and Fluorescent ① |
|---|---|---|
| Clean location—good maintenance | 0.9 | 0.8 |
| Clean location—poor maintenance | 0.7 | 0.7 |
| Dirty location—good maintenance | 0.8 | 0.7 |
| Dirty location—poor maintenance | 0.5 | 0.5 |
| Very dirty location—good maintenance | 0.7 | 0.6 |
| Very dirty location—poor maintenance ② | 0.4 | 0.4 |

①Mercury and fluorescent lamps have a longer life than incandescent lamps so are not serviced so often.
②This is a condition usually found in steel mills.

### LAMP OUT FACTORS

| Condition | Factor |
|---|---|
| Incandescent and mercury lamps—good maintenance | 0.95 |
| Incandescent and mercury lamps—poor maintenance ③ | 0.90 |
| Fluorescent lamps—good maintenance | 0.85 |
| Fluorescent lamps—poor maintenance | 0.80 |

③This is a condition usually found in steel mills.

### VOLTAGE DROP FACTORS

| Condition | Factor |
|---|---|
| Socket volts 2 per cent less than lamp voltage rating—incandescent | 0.94 |
| Volts at transformer terminals 2 per cent less than transformer rating—mercury | 0.94 |
| Volts at ballast terminals 2 per cent less than ballast rating—fluorescent | 0.98 |
| Socket volts 3 per cent less than lamp voltage rating—incandescent | 0.91 |
| Volts at transformer terminals 3 per cent less than transformer rating—mercury | 0.91 |
| Volts at ballast terminals 3 per cent less than ballast rating—fluorescent | 0.97 |
| Socket volts 5 per cent less than lamp voltage rating—incandescent | 0.85 |
| Volts at transformer terminals 5 per cent less than transformer rating—mercury | 0.85 |
| Volts at ballast terminals 5 per cent less than ballast rating—fluorescent | 0.95 |
| Socket volts 10 per cent less than lamp voltage rating—incandescent | 0.70 |
| Volts at transformer terminals 10 per cent less than transformer rating—mercury | 0.70 |
| Volts at ballast terminals 6 per cent ④ less than ballast rating—fluorescent | 0.93 |

④When fluorescent lamps are operated at ballast terminal voltages greater than 6 per cent less than ballast rating, their operation is erratic.

### INTERCEPTION FACTOR

Light on the work is subject to interception by structural parts of the building, machine parts, the material worked on and the operator's body and his tools. High interception factors are the reason for the popularity of local lights.

The interception factor may be closely approximated by taking the ratio lumens in the 0°-40° zone to the lumens in the 0°-90° zone from the photometric curve of the luminaire used. The interception factor is usually found in this way when the average flux method of footcandle calculation FC = Lumens utilization divided by the Area. The interception factor can also be incorporated into the point by point footcandle calculation $FC = cp \cos^3 O \div h^2$ by omitting contributions from lighting units at angles greater than 45°. For steel mills the interception factor of a high bay unit will be approximately .8 and for an RLM unit approximately 0.5.

### ATMOSPHERE ABSORPTION FACTOR

The atmosphere absorption factor does not always exist in such magnitude that it is worth considering. There are locations, however, such as slag quenching, scale breaking, open hearth pouring floor, etc. where it is a factor worth considering and is approximately 0.5. This factor must be measured in similar existing facilities for more exact values. Such measurements in an aviation engine test all showed an atmosphere absorption factor of 0.6 after 30 minutes of engine operation.

An example of the in service factor for hot strip finishing would be as follows: 1000 watt incandescent lamps depreciation 0.83, dust and dirt 0.4, lamps out factor 0.9, voltage drop factor 0.94, interception factor 0.8 or a final factor of $(.83 \times .4 \times .9 \times .94 \times .8) = 0.22$. If an in service illumination of 10 footcandles is desired in the hot strip finishing, the design illumination must be $10 \div 0.22 = 45$ footcandles. This may seem a very high factor and not in keeping with good practice in steel mills. It must be remembered, however, that in the past the only in service factor that has been taken into account is 0.7 for dust and dirt depreciation, which in turn would mean a design illumination of $10 \div 0.7 = 14$ footcandles. Check footcandle measurements are always made out in an open aisle and care is taken to prevent shadows of the reader's body, column or machine parts from falling on the light meter. Also, if some lamps are out at the particular station, that station is skipped as not being representative. Footcandle readings are then corrected for low voltage. Measurements are taken when the job is new and before the vicissitudes of service have time to become a factor. Footcandle readings are practically never made on the work, and with the operator on his job and the machine in actual operation. The explanation of the apparent discrepancy between the 45 and 14 footcandles design illumination is that 10 footcandles in service is not received on the work when 14 footcandles design illumination is used. Perhaps 10 footcandles in service is not required for a hot strip finishing mill. I have calculated back from data on 10 hot strip finishing mills in various parts of the country and find an average of 1.14 watts per square foot with a maximum of 2.05 and a minimum of 0.54. At a height of 40 ft one watt per square foot in a high bay unit will give 11 footcandles on paper and with the 0.7 factor usually used, the illumination would be 7.7 footcandles. The actual in service footcandles on the

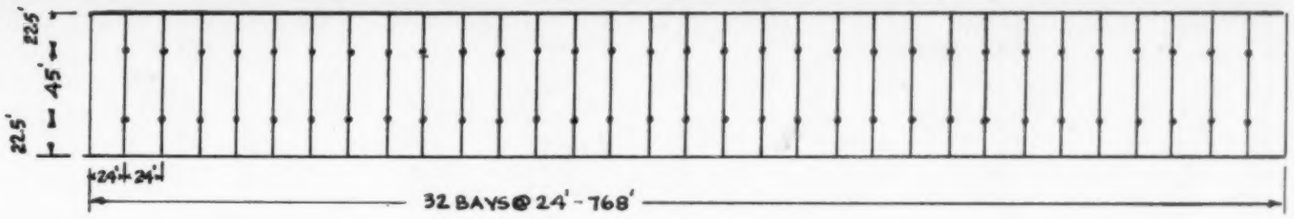
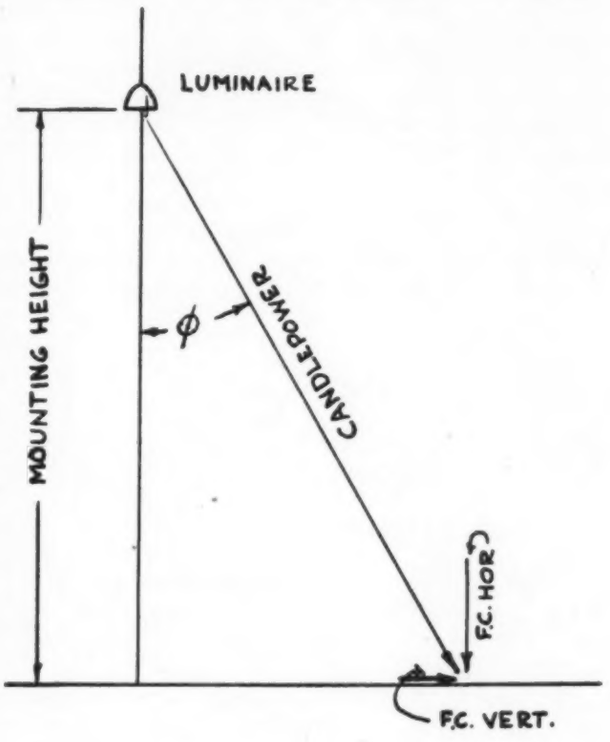



**Figure 1 — Plan of hot strip mill showing arrangement of lights.**

▲

**Figure 2 — Diagram showing relation of factors used in calculating footcandles by the point by point method.**




work is $11 \times 0.22 = 2.4$ footcandles. The in service factor at the Bridgeport Brass Co. given here showed a measured in service factor of 0.20 and calculations based on the above factors give 0.22.

## ECONOMIC ANALYSIS

A new technique has been developed for the appraisal of various lighting systems on a cost basis. It is well known that a 40 watt fluorescent lamp gives 4.5 times as many lumens as a 40 watt incandescent lamp, and has 2.5 times the life. It does not follow that a fluorescent lamp will give more footcandles on the work than an incandescent lamp or that it will cost less to operate. There are several factors that determine the cost of lighting and all of these must be taken into consideration for each individual job before a complete comparison can be made. As an illustration of the necessity of making such an economic comparison, which includes all of the factors of first and operating cost I have seen instances in steel mills where neck silvered lamps were used instead of high bay reflectors because when the lamp burned out it was replaced by a new clean lamp. An economic comparison shows this to be a wasteful practice because on an equal in service footcandle basis the silvered lamps cost more to operate than high bay reflectors.

Before an economic analysis can be made it is necessary to know definitely the constant factors which form the basis for the analysis, such as current cost in dollars per kwh, yearly burning hours, and the required in service footcandles. A typical economic analysis follows:

The job is a hot strip mill in a building 768 ft x 90 ft x 48 ft 6 in. to roof truss. The desired in service footcandles is 2.5. Current cost is $0.01 per kwh, and burning hours per year are 5000.

As already shown the in service factor will be 0.22 which brings the design illumination to $2.5 \div 0.22 = 11.3$. Using the average flux method of calculation for 1000 watt incandescent lamps, the area x $11.3 = 21{,}000 \times 0.55$ and solving the area per unit = 1020 square ft. The logical layout would be two rows across the width of the bay at 45 ft centers, with units on each truss at 24 ft along the mill length and this layout gives 1080 sq ft per unit. A total of 62-1000 watt units would be required. See Figure 1.

| | | |
|---|---|---|
| **First cost** | | |
| A. | Cost of luminaires (62 x $20.67) | $1281.54 |
| B. | Cost of wiring (62 x $15.00) | 930.00 |
| C. | Subtotal for fixed changes | $2211.54 |
| D. | Cost of lamps (62 x $3.50 less 30 per cent) | 151.90 |
| E. | Total first cost | $2363.44 |
| **Yearly operating cost** | | |
| F. | Current cost (62 x 1 x 5000 x $.01) | $3100.00 |
| G. | Lamp replacement cost $\left(\frac{151.90 \times 5000}{1000}\right)$ | 759.50 |
| H. | Labor cost of relamping and cleaning (62 x $.90 x 5) | 279.00 |
| I. | Amortization (10 per cent of $2211.54) | 221.15 |
| J. | Interest and taxes (10 per cent of $2211.54) | 221.15 |
| K. | Total yearly operating cost | $4580.80 |

*Point by point versus average flux method of calculation* — The average flux method of calculation is based on the flux definition of a footcandle which is the illumination on a surface one square foot in area over which there is uniformly distributed a flux of one lumen. The formula becomes:

$$\text{Footcandles (horizontal)} = \frac{\text{Lamp lumens}}{\text{Area per lamp}} \times \text{Coefficient}$$

of utilization $\times$ in service factor.

This formula is easy and quick to use but the selection of the proper coefficient of utilization and in service factor introduces errors. This formula is not intended for use where actual footcandles on the work is desired. It was developed for calculating the average horizontal

**Figure 3 — Improved crane light with vibration proof nuts and lamp grip socket.**

▲

**Figure 4 — Dust proof fluorescent light with high stress lenses that are smooth on the outside surface and arranged for servicing through steel side door.**

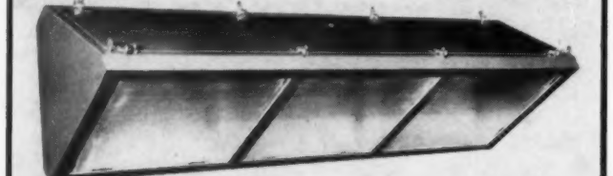
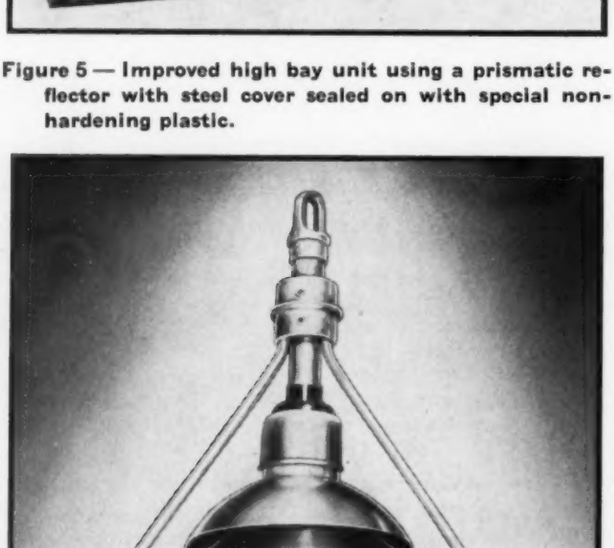


**Figure 5 — Improved high bay unit using a prismatic reflector with steel cover sealed on with special non-hardening plastic.**



footcandles in any empty room. It will not, for instance, give the footcandles at the rolls of a sheet mill.

The point by point method of calculation is based on the candlepower definition of a footcandle which is the illumination on a surface, all points of which are at a distance of one foot from a uniform point source of one candle. The formula becomes (see Figure 2):

$$\text{Footcandles (horizontal)} = \frac{\text{Candle power at } \phi}{(\text{Mounting height})^2} \cos^3 \phi \times \text{in service factor}$$

$$\text{Footcandles (vertical)} = \frac{\text{Candle power at } \phi}{(\text{Mounting height})^2} \cos^2 \sin \phi \times \text{in service factor.}$$

Modern conception of seeing makes it necessary to know the illumination on the actual work and this can be calculated only by using the point by point method. Illumination can be calculated on any plane — vertical, horizontal or between. The interference factor which is a part of the in service factor, and which is the most difficult one to evaluate can be determined exactly by using elevations of the building, machine, work and operator. The point by point method of calculation should become universally used by engineers.

## STUDIES IN SEEING

It is, or course, well known, but often forgotten that we see an object by light reflected from it. Footcandles represents light that falls on an object and Footlamberts represents light that is reflected from it. In the case of a 100 per cent reflecting surface, a footcandle and a footlambert would be the same. The object worked on should be at least as bright as its immediate surroundings, but not brighter than three times the surroundings.

The primary function of the eyes is for orientation and not for seeing. Many industrial operations require light for orientation only and not for actual seeing. These considerations explain why local lights are so necessary on machines where the actual work must be seen and why so many operations in a steel mill are easily done by light for orientation only. Many operations, which for a beginner require light for seeing, require only light for orientation for the experienced operator.

When it is realized that the in service footcandle values on the work in a hot strip mill is 2.5 footcandles and that the eye sees 2.5 times the reflection factor of steel 0.3 or 2.5 x 0.3 = 0.75 footcandles, it will be realized that very little seeing is done and instead the work is done by orientation.

*Light meters* — Photronic cell light meters will measure only incident flux or footcandles and cannot, with any degree of accuracy, measure reflected light or footlamberts. They are easy to read which accounts for their popularity. The equality of brightness, light meters will measure accurately either footcandles or footlamberts and should be used for measuring the light that the eye sees from the work.

*Fluorescent lighting* — Many large fluorescent instal-

**Figure 6 — Steel covered alzac high bay unit with bottom cover of shatter proof glass.** ↑

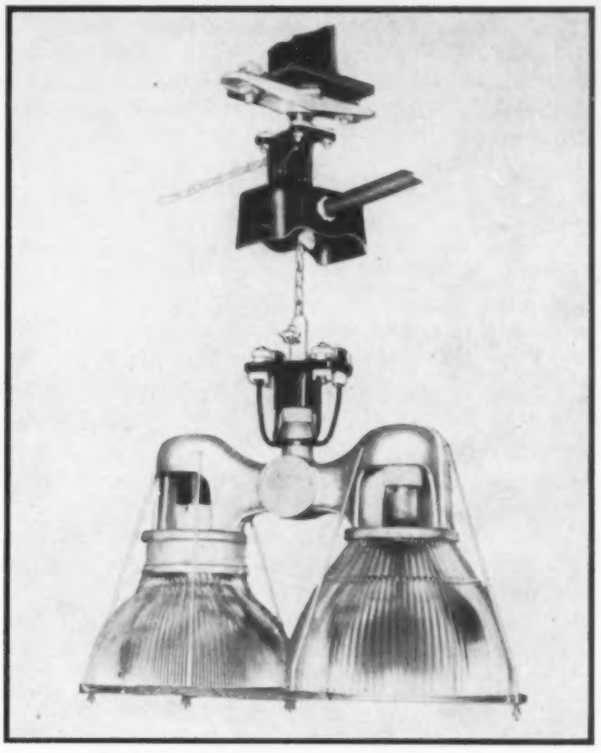


**Figure 7 — Four contact disconnecting hanger with a twin combination incandescent mercury unit.** →

lations have been placed in service during the war in high bay airplane plants. These installations have a high first cost, high operating cost and impractical maintenance problems. Fluorescent lighting is definitely not suitable for high bays because of their low utilization efficiency and high upkeep cost.

Fluorescent lighting is satisfactory for offices, drafting rooms and some low bay lighting where it is supplemented with local lights on machine tools. Properly installed fluorescent lighting is good for bench work.

*Trends in steel mill lighting equipment* — There is a definite trend toward improvement in the mechanical and electrical quality of lighting equipment designed for steel mills and similar heavy duty applications. It is realized that the savings in first cost of cheap lighting equipment is easily lost several times in the cost of repairs and replacements. Heavy construction, generous use of metal, elimination of small screws, ¾ in. minimum pipe size for suspension, better socket construction, permanence of reflecting materials and, easy cleaning are characteristics of new steel mill equipment.

## NEW EQUIPMENT AND IMPROVEMENTS

*Glass* — Several improvements have been made in glass for reflecting and refracting light. Hi-stress glass is a heat tempered glass that will withstand a mechanical shock of 10 foot pounds and a thermal shock of 100 C. When broken, this glass crumbles into small cubes that are not sharp.

Infra red transmitting glass that passes the infra red rays and suppresses the visible rays has been developed for military purposes and will no doubt find uses in peacetime industry. Infra red absorbing glass has been developed that absorbs 80 per cent of the infra red light and transmits 80 per cent of the visible radiation. This infra-red absorbing glass was developed for use in operating room lighting systems where it is desired to secure approximately 1000 footcandles without the attendant heat. It may have some application in the steel industry for viewing doors in furnaces and similar use. These new types of glass are now in production and are being used for many military applications as well as industrial use.

*Plastics* — Plastics have been used as a substitute for glass for many expendable lighting uses. The inherent disadvantages of plastics for lighting use are deterioration with age, heat deterioration, solarization, and the fact that plastics are easily scratched. Where its light weight and shatter proof qualities outweigh its lack of permanence, plastics, especially lucite, may find some postwar lighting uses.

*Outdoor lights* — Special lighting equipment has been developed during the war for the illumination of aeroplane engine test cells. This equipment is oil tight and air tight and is designed to withstand the severe vibration condition of the service. The light distribution and mechanical construction are ideal for outdoor lighting where the lighting equipment can be mounted on or flush in a wall. It is available in sizes for 100 to 500 watt standard lamps.

*Crane lights* — Mechanical improvements have been made in crane lights by the use of airplane type vibration proof nuts to replace regular nuts and cotter pins. Lamp grip type sockets are used to prevent the lamp from coming unscrewed in the socket due to vibration. Metal parts have been made heavier and interchangeable in the different sizes.

*Dust tight fluorescent fixtures* — A dust tight fluorescent unit for low bay use, which is approved by the Underwriters' laboratories for class II group E, F and G application will utilize two or three 40 watt fluorescent lamps. The unit is made of 16 gauge steel and is unique in that the bottom high stress glass lenses are

cemented permanently in place and access to the lamps and ballasts are through a gasketed steel door in the side of the unit. This makes possible construction that is permanently tight even after successive relamping. In the table showing dirt and dust depreciation factors, the factors for various locations and various degrees of maintenance for this unit will be as follows:

| Condition | Factor |
|---|---|
| Clean location—good maintenance | 0.95 |
| Clean location—poor maintenance | 0.9 |
| Dirty location—good maintenance | 0.9 |
| Dirty location—poor maintenance | 0.85 |
| Very dirty location—good maintenance | 0.85 |
| Very dirty location—poor maintenance | 0.65 |

*High bay units* — Mechanical improvements have been made in the prismatic glass high-bay units by making a permanent seal between the glass reflector and the steel cover. The glass reflectors will be made of high stress glass as soon as the Navy production program permits.

During the war aluminum reflectors were prohibited. Now, however, aluminum reflectors of the anodized finish type are again available.

An improved alzac aluminum reflector with a tempered glass removable bottom cover is now available in narrow, medium and wide light distributions for 750 to 1500 incandescent and 400 watt mercury lamps.

Twin, triple and quadruple high bay units have been made for use where high footcandle illumination is necessary, such as chipping. These units use either all incandescent or combination incandescent and mercury lamps.

A disconnecting hanger is now available having four contacts instead of the conventional two so that combination incandescent-mercury units can be lowered for maintenance without lowering the mercury transformer.

# DISCUSSION


PRESENTED BY

F. O. SCHNURE, Electrical Superintendent, Bethlehem Steel Company, Sparrows Point, Maryland

L. V. BLACK, Superintendent, Electrical Department, Bethlehem Steel Company, Bethlehem, Pennsylvania

D. H. TUCK, Electrical Engineer, Holophane Company, Inc., New York, New York


**F. O. Schnure:** Our maintenance of fixtures is very bad. It was hard to get the necessary work done to keep the mill operating during the war, but that condition should improve as we go along.

In laying out a new mill job recently, we attempted to give a little more light than previously. We are limiting voltage drop by installing a multiplicity of transformers in the roof trusses and controlling them from the ground by suitable remote control in the primary of the transformer.

In addition, with the idea of providing good illumination and only using it when required, and thus keeping at a minimum the overall cost of power and lamps, we are applying in this mill electric eye controls to turn the lights on and off as required. One of the hardest jobs in the mill is to get the lights turned off when daylight appears and as a result they burn entirely too much during the daylight hours.

**L. V. Black:** Many steel plant men have realized that an installation which originally produced a satisfactory intensity will in a short time provide an inadequate intensity in the same area due to short lamp life, low voltage, the accumulation of dust and dirt, and the absorption factor which is more prevalent in an open type high bay unit.

In most instances where the in service factor was considered in the original design, criticism was voiced on the high intensity upon installation and the decided drop after the first few months of operation. We have measured by actual tests a drop of 42 per cent after a three months operating period which was caused by the accumulation of dust and burning lamp hours. However, after cleaning and relamping an increase of 38 per cent was noted bringing the intensity to within 4 per cent of the initial light output.

Light intensities required in an airplane assembly plant are much higher than the requirements of a steel mill. However, there are some locations in various shop inspection beds that do require a much greater level of illumination than the average steel mill requires elsewhere. We have found that, where the mounting heights demand the use of 1000 or 1500 watt lamps, considerable trouble is experienced with burnt-out sockets due primarily to improper ventilation of the fixture. The design of sockets for high wattage lighting units should be checked for greater clearances between polarities and more substantial contact points to eliminate gaps or arcs and the eventual shorted socket. This is especially true in the Bethlehem plant where most of the lighting is operated on 240 volts direct current.

While mercury and fluorescent lamps have their merits and particular applications, it must also be remembered that they are designed for 60 cycles and not 25 cycles or direct current operation. Resistors and ballasts can be secured for the operation of fluorescent lighting on direct current circuits, although such connections will lower the initial lumen output and at the same time double the cost of operation, as the resistor consumes as much current as the lamp itself. Therefore, from the efficiency standpoint, operation of fluorescent lighting on direct current circuits is not recommended.

Mr. Tuck mentioned improved crane lighting, upon which subject a great deal might be said. Several months ago we installed in a number of our shops 500 watt hand controlled portable floodlights mounted on a bracket attached to the operator's cab and suspended on shock absorbing hangers in order that jolts and vibrations might be absorbed. This installation has proven very satisfactory as the operators are in a position to direct the light on the lift anywhere in the shop. The old method consisted of permanent mounted units that invariably would not illuminate the area where the lifts were to be made. A noted increase of speed and time between lifts was noted with a much safer working condition for the chainman and helper. Safety in a shop is of vital importance to all concerned.

Maintenance is also an important factor to be taken into consideration when selecting fixtures for a new installation. Aside from high labor rates, interference with production is a cost item which cannot be accu-

rately calculated. When designing a new lighting layout, care should also be taken in selecting a fixture that has proper ventilation facilities in order that the heat radiated might be properly dispelled, thus eliminating additional socket replacements.

Another important item in the selection of a lighting fixture is to consider the type of reflector best suited for the job. If the new installation is for an area where acid fumes have a tendency to accumulate, an acid resisting reflector that will not corrode or deteriorate in a short while should be used. Our experiences in the past have shown that many different types of reflectors have a characteristic of losing their brilliancy and reflecting value in a short period of time due to dust and dirt deposits on the reflector. Why can't the manufacturers design and build a fixture that will withstand and eliminate all of these faults which would automatically reduce the maintenance cost of operations? I am sure a fixture of this type would be welcomed with open arms in our plant as well as most other industrial plants employing this type fixture.

**D. H. Tuck:** Mr. Schnure mentioned voltage drop. It should be counted on because even the best installations have some voltage drop, and it is not unusual to find 8-10 or even 15 per cent voltage drop in the plants. I saw a lumber plant where the voltage was so low the mercury lights wouldn't light at all, and the incandescent lamps had 80 volts at the socket, where they were supposed to have 120.

Referring to Mr. Schnure's remarks about high voltage through the top of the mill, Youngstown Sheet and Tube Company did something similar to reduce the voltage drop from the branch circuits down to the switches. They ran high voltage through the top of the mill, put the transformers up there in sections and broke the primary with contactors. They were well satisfied with that job. Later a steel mill in Kentucky did the same thing.

I had occasion to measure depreciation in an air-conditioned office recently. The lamps had been religiously renewed; there were no burnt-out lamps. That meant, of course, that some of the lamps were new. All fixtures were totally enclosed in a clean room. The depreciation in a year's time was exactly .5, due to dust and dirt and to some of the lamps.

The socket is about the poorest piece of equipment put on the market today. The distance between the polarity gives about an eighth of an inch of protection. There is much socket trouble and as long as we get the sockets we are receiving now, there will always be trouble. We have been after the socket manufacturers and the only answer we get is that sockets are a highly competitive item and have to be made as cheaply as possible.

## *Bloomquist* PAPER

(*Continued from page 84*)

Step-by-step expansion of the 22 kv system made up of units, enabled the cost of a complete program to be spread over a period of years; yet the cost of doing the job by steps is practically no more than if it were all done at once. For example, the first step of the program is shown in Figure 5.

The 25,000 kw turbine unit was connected through a step-up transformer and breaker to a 22 kv bus. A 15,000 kva step-down transformer was installed for the tie connection to the existing 6900 volt system. This transformer was selected at 15,000 kva to be a duplicate of those at the step-down substation; therefore, one spare served both purposes.

There will be two outgoing feeders from the first bus section. When the second turbine generator is installed, one of these feeders will be transferred to the bus section of the second unit.

The second step can consist of adding another turbine and unit substations and transmission lines as desired. From then on, the system can be built up in an orderly manner to the ultimate which was shown in Figure 2.

### CONCLUSION

Although the above discussion relates to a specific example, many of the factors apply generally and should be considered in any plan of major expansion or modernization of the power system. Some of these factors are:

1. Selection of the main distribution system voltage level higher than 6.6 kv utilization voltage. This is especially important when large blocks of electric power are involved. However, where utilization is at 13.8 kv, studies have shown that it is economical to use 13.8 kv for main generation and distribution also.
2. Use of a loop type main distribution system. Such a system is readily expanded and additional loads can be tapped at any place with little if any change to the existing system. Such an arrangement, with proper relaying, will give excellent service reliability.
3. Consideration of individual changes, additions or modifications as part of an overall system plan.
4. Simplicity in system arrangement and operation.

## *Janecek* PAPER

(*Continued from page 94*)

it is understood just how much hot blast the furnace will take and to what extent the burden ratio can be increased will the advantages of elevated pressure be fully realized. Through elevated top pressure, it becomes possible for a large diameter blast furnace to produce tonnages per square foot of hearth area which have been accredited only to small furnaces. This is because it becomes possible to blow more wind, with the ratio of wind blown to square feet of hearth area approaching the ratio used on small furnaces, thus obtaining wind distribution in the hearth on relatively the same basis as the smaller furnaces.

If the periods outlined in the foregoing are adjusted for the abnormal delays shown, tonnages will show a considerable increase. It can be said that, when mechanical difficulties are finally overcome, elevated pressure operation will prove advantageous whether blowing present wind volumes or increased volumes proportional to the increase in pressure.

# *Postwar* TECHNICAL AND ENGINEERING *Education*

***. . . . of vital concern to industry are their engineering replacements . . . . the probable postwar shortage of engineering graduates and the problem of the returning veteran will affect these replacements . . . .***

*by G. C. K. Johnson*

UNIVERSITY OF ALABAMA

TUSCALOOSA, ALABAMA

▲ THE recent war has been a technical one. Never in the history of warfare has "so much depended on so few," to paraphrase Winston Churchill. The technical aspects of the war just ended are appalling. The development and perfection of radar, the development of cargo-carrying aircraft, the jet propulsion plane, to say nothing of the atomic bomb, are but a few of the contributions of science to modern warfare.

Now we are faced with the conversion of these and hundreds of other scientific developments to normal peacetime usage. This conversion must progress immediately, despite an appalling lack of trained engineers and scientists and despite violent labor unrest.

Dean S. C. Hollister of Cornell, in reporting the findings of his committee to the Society for the Promotion of Engineering Education, stated that industry in the United States had been denied the services of young engineers since 1941, and that by 1949, when the first possible approximately normal class will graduate, there will be a direct need for at least 55,000 engineers. Dean Hollister plotted the number of graduating engineers from 1910 to the present time by years, and from these data obtained a very definite trend. Some of these figures may be of interest. In 1910 we graduated just over 2000 engineers. By 1926 we were graduating engineers at the rate of 8000 yearly. By 1942 we were graduating almost 15,000 engineers a year. Thus, from 1910 to 1942 the engineering schools of the United States increased their production 750 per cent. In 1943, due to the apparent necessity of drafting all physically fit young men, the graduating class dropped to 10,000. By 1944 we had returned to the production figure of 1910 — slightly in excess of 2000. Should our government cancel the Selective Service Act immediately, it is quite likely that we could resume normal, or very nearly normal, graduating classes by 1949. Following the trend of the curve, that means that we will graduate about 17,000 engineers in 1949. If we sum up the area between the estimated trend of engineering graduates and the actual graduates, we find that for the period between 1943, when graduating classes dropped in size, and 1949, a difference of 94,000 exists. I presume that Dean Hollister had statistical data which indicated that only a little over 50 per cent of the graduating engineers actually became practicing engineers, because he arrived at the decision that our country would face an engineering personnel shortage of 55,000 by 1949.

Dean A. Potter of Purdue arrived at a similar figure through entirely different channels. Dean Potter found that Purdue had been placing the bulk of its engineering graduates with 400 firms. He and his staff then analyzed these firms and selected 105 which represented, in their opinion, a good cross-section of American industry. These 105 firms were selected to represent not only a fair balance as to size, but also a balance as to type, since both the type and size affect the number of engineers required by a company. This list of firms included 7 aircraft companies, 25 chemical and rubber companies, 3 construction companies, 18 electrical companies, 22 machinery and automobile companies, 3 railway and railway supply companies, 6 steel and raw material companies, 6 utilities, and 15 miscellaneous companies. Dean Potter then wrote a letter to each of these firms, asking specific questions concerning their immediate and future needs for engineers. The returns indicated an average present need of 48 engineers per company, and a permanent need of 36 per company. Multiplying this latter figure of 36 by a figure representing all of the United States industry, Dean Potter arrives at a lack of 50,000 engineers to fill permanent positions in American industry.

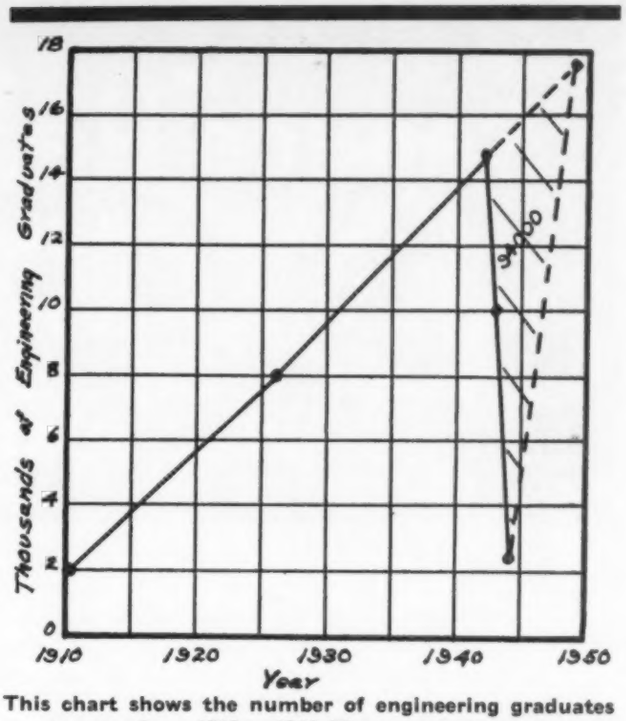
Not only were few United States boys allowed to

Presented before A. I. S. E. Birmingham District Section Meeting, November 26, 1945.

study engineering during this period but almost all the physically fit were inducted into the armed forces immediately upon graduation. Contrasting this situation with that of both our allies and our enemies, we find quite a different story. Special Bulletin No. 22 issued by the National Research Council introduces some interesting and perhaps surprising information. It was revealed in this publication that the 1944-45 enrollment of engineering students in the United States was only 36 per cent of the enrollment in 1939-40. Further, the bulk of this 36 per cent were freshmen under 18 years of age, awaiting almost certain induction into the armed forces when reaching the age of 18. Contrasting this situation with that of all foreign countries, we find that their enrollment in not only engineering but in all professional and scientific curriculums exceeded the highest prewar enrollment. Desperate as Great Britain, Germany and Japan were for men, they never once deviated from the policy of making it possible, yes, even insisting that every potential engineer and scientist be trained and made available for industry. We won the war, in spite of our policy, but now stand a good chance of losing the peace because of the lack of trained personnel to carry on a successful reconversion to peacetime pursuits.

It is hard to estimate what percentage of the approximately 160,000 men who were graduated in engineering since 1930 were in the armed forces. A high percentage of these men will return, not necessarily to their old jobs, but to civilian life and to a job somewhere in industry. It is to be expected that their military experience will be of little value to them in their civilian jobs. Many of these young men left college or the drafting board and rose to the ranks of major and even colonel. Imagine if you can their return to civilian life. These young men have tasted authority, prestige, money and glamour, and must now return to a routine civilian job, at much smaller pay and little or no authority. Some of you may have tasted similar dregs in the crash of 1929. Industry is unable, and naturally unwilling, to offer the returning soldier a position comparable to that of his military rank. The reasons, I believe, are obvious. First, in very few cases has the soldier's military experience paralleled any type of industrial experience. Second, the philosophy of war and war production is very wasteful and cannot be tolerated in normal and competitive business. Third, the average soldier had little direct use for the specific knowledge gained in college and in industry, and therefore has permitted much of this information to slip from his memory. Fourth and last, the new technical discoveries brought about by the impetus of war will be like Greek to him, and he must digest at least those new discoveries in his field before he can assume his rightful place beside his brother who fought the war from the engineering office.

The serviceman is facing an extremely difficult conversion problem. Many of these boys have assumed family obligations since leaving college and industry. Most of us have followed the same pattern, though perhaps under different circumstances, and cannot and should not criticize the married serviceman for doing just as we would do. With more mouths to feed, he is going to need more salary. In addition, the cost of living has increased sharply since 1939, despite government figures to the contrary.




**This chart shows the number of engineering graduates per year from 1910 to 1944. The cross-hatched area indicates a deficiency of 9400 engineering graduates by 1949.**

It seems to me that we are faced with a problem that has no blanket answer. Each case will be an individual puzzle and must be solved as such. I believe that part of the solution lies in individual counseling and guidance — not the ordinary kind, but a new type carefully prepared and executed by trained specialists. Perhaps the counselling service inaugurated by many progressive industries during the war period, designed to minimize labor turnover, will serve as a background for this new counselling service. I believe that the veterans have had an experience that will stay with them, much of which can be adapted for real service in industry if we will only take the time and trouble to locate, catalogue, and use the experience.

Harley A. Smith, chief of the Vocational Rehabilitation and Education Division of the Veterans Administration of Alabama, released some interesting data recently, stating that 1523 Alabama veterans were now studying under the G. I. Bill of Rights. Of these 1523, 1076 were engaged in institutional study. This, I take it, means enrolled in institutions whose primary purpose is education or training, either cultural, professional, or vocational. He specifically stated that of the 1002 enjoying the benefits of Public Law 346, 454 were enrolled for college work. He did not make a similar breakdown of the 521 veterans who are receiving benefits under Public Law 16. Of the 436 veterans enrolled at University of Alabama 104 or 24 per cent have registered in engineering.

Some of the leading engineering schools in the country are anticipating as much as 100 per cent increase in their enrollment in the years immediately following the cancellation of the Selective Service Act. I wonder if industry can absorb this increase. I wonder, too, if we engineers are smart enough and sufficiently well trained to make use of the fundamental scientific data dis-

*(Please turn to page 106)*

*You can:*

# Reduce Heating

## *in Panels and Switches*

## Keep circuits operating – Prevent costly shutdowns *by installing* FUSETRONS

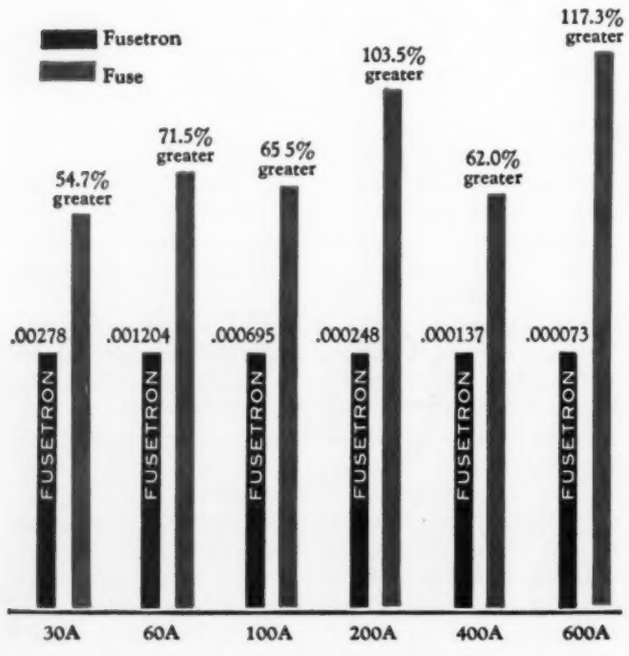
Fuses, like all other protective devices, operate from heat created by the current flowing through them. Thus they produce some heat even in normal operation.

This heat must be dissipated from switches and panels through the air, through metal parts and through the wires connected to such enclosures.

Sometimes the heat is not dissipated fast enough—so it piles up in switches or panels.

This piled up heat over-heats fuses and reduces their carrying capacity. Then fuses often blow even though not loaded to their rated capacity.

**LOOK AT THE RESISTANCE OF FUSETRONS COMPARED TO THE LOWEST RESISTANCE FUSE**




Resistance shown at full load in ohms. Chart shows 250 volt sizes. 600 volt sizes show similar results.

To solve the heating problem by putting in larger metal parts or wires to conduct heat away faster is always costly. A more logical answer is to cut down heat at its source by using Fusetrons—they produce less heat because they have less electrical resistance than ordinary fuses.

### *Cooler Operation of Switches and Panels Reduces Needless Blowing of Fuses*

Install Fusetrons in your switches and panels and they will operate much cooler than with fuses because the heat produced by the flow of current is proportional to resistance and Fusetrons have very much less resistance than ordinary fuses.

This cooler operation means the elimination of needless blows and useless shutdowns that are the result of heating in fuses.

Cooler operation also adds to the life of panels and switches.

### *Here's PROOF Fusetrons Reduce Heating*

Says an executive of a large Detroit Company. (Name on request.) "One-time fuses formerly used in a lighting circuit feeder panel got so hot that every fuse burned itself up and had to be replaced every month. Our Chief Electrician changed the fuses to Fusetrons of the same size. After three months, only one circuit had opened and the panel was very much cooler than it had been with one-time fuses. Subsequently we changed all our fuses to Fusetrons."

**BUSS**

*Fusetrons do everything fuses do. They open on harmful overloads and on short-circuits stop the flow of current quickly and safely, all of which is confirmed by the Underwriters' Laboratories Label . . . and in addition you can*

# Get many kinds of protection, *heretofore* not available – *by installing* FUSETRONS throughout the entire electrical system

★ ***Entirely wipe out needless blows caused by motor starting currents or other harmless overloads.***

Fusetrons have tremendous time-lag. They hold 500% load more than 10 seconds whereas most sizes of ordinary fuses blow in less than one second. They won't open on starting currents or harmless overloads (heavy overloads for a short time or light overloads for a longer time). Fusetrons won't shut down a circuit needlessly. They open only when something goes wrong.

★ ***Give Thermal Protection to Panelboards and Switches***

The thermal cutout in the Fusetron will open whenever its temperature reaches 280° F. Thus if poor contact heat develops from any cause the Fusetron cuts off the current before damaging temperatures can be reached.

Ordinary fuses can't so protect because the temperature of the link must reach 786° F. before it will melt out.

With Fusetrons you are warned that a minor maintenance job is needed instead of having panel or switch damaged or destroyed by poor contact.

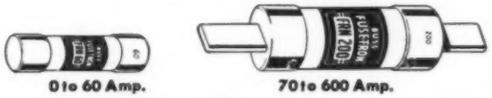
★ ***Prevent Needless Blows caused by Heating in Panels and Switches***

(*See Opposite Page*).

★ ***Permit use of larger motor or adding more motors on circuit WITHOUT installing larger switch or panel***

The operating load on Fusetrons can be close to their ampere rating because Fusetrons hold starting currents. But ordinary fuses must be installed oversize because they lack sufficient time-lag to hold starting currents.

## WHAT IS THE FUSETRON?



**0 to 60 Amp.** **70 to 600 Amp.**

The Fusetron is a DUAL element device—A Fuse to which is added a Thermal Cutout.

The result is a fuse with tremendous time-lag and much less electrical resistance.

Fusetrons have the same degree of Underwriters' Laboratories' approval for both motor-running and circuit-protection as the most expensive devices made.

*Fit standard fuse blocks*

Fusetrons are made to same dimensions as ordinary fuses and fit all standard fuse holders.

They are obtainable in all sizes from 1/10 to 600 ampere—in both 250 and 600 volt types.

Also obtainable in plug type and Tamper-resisting type (Fustats) for 125 volt circuits.

**Their Cost is Surprisingly Low**

By replacing oversize fuses with Fusetrons, you can load panels or switches near their capacity. A larger motor or additional motors can be installed without the trouble or expense of changing the panel or switch.

★ ***On new installations, PROPER size switches and panels can be used instead of OVERSIZE***

With ordinary fuses, switches and panels must be oversize because fuses larger than the operating load must be used to hold starting currents.

But Fusetrons hold starting currents, therefore, PROPER size switches and panels to fit the load can be installed, saving money and space.

★ ***Protect motors against burnout***

On normal installations, Fusetrons used in a size near ampere rating of motor will protect it against burnout from lack of oil, worn bearings, tight belt or anything that causes a dangerous electrical overload—yet their tremendous time-lag keeps them from blowing on motor-starting current.

★ ***Give DOUBLE burnout protection to large motors.***

Larger motors already equipped with overload protection sometimes burn out due to thermals or relays failing to operate. Replace fuses used for short-circuit protection with Fusetrons of size near motor rating and they will protect motor against burnout from any electrical overload, entirely independent of other overload device.

★ ***Provide simplest way to stop burnouts from single phasing***

When single phasing occurs, increased current flowing through remaining phase will open Fusetrons (if size used is near the rating of the motor) and shut down motor. Never before has such dependable single phasing protection been available.

★ ***Make burnout protection of SMALL motors simple and inexpensive***

Small motors have generally been operated without burnout protection because the cost of protecting them has been too great compared to cost of replacing motor. Now for the little cost of installing a Fusetron of proper size, any motor can be given safe, dependable burnout protection.

★ ***Protect Coils, Transformers and Solenoids against burnout***

Install a proper size Fusetron. It won't open on harmless overloads of normal current surges, yet should a dangerous overload occur for any reason it will cut off the current to prevent a burnout.

ACT ON THE FACTS; Even one needless shutdown or one lost motor or one destroyed panel may cost you more than replacing every fuse with a Fusetron. Don't risk such losses, change over the whole plant to Fusetrons at once.

# FUSETRONS

## GET THE FACTS — *CHECK THE COST*

BUSSMANN MFG. Co., University at Jefferson, St. Louis 7, Mo. (*Division McGraw Electric Co.*) 146

Please send me complete facts about BUSS Fusetrons.

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covered during the war, for our peacetime benefits. We as engineers have long felt that it was the scientist's job to discover the laws and forces of nature and that it was our job as engineers to apply these laws and harness these forces for the use of man. Most of the basic research and far too much of the application and use of the principles discovered were performed by pure scientists — the mathematician, the physicist and the chemist, not the engineer, and the reason is obvious. We are so apt to neglect and forget the little basic science we learned in college. How many can still use the calculus with ease and confidence? How many remember even the basic phases of physics not directly associated with their particular branch of engineering? I don't know whether this condition is attributable to teaching methods and curriculums in college or whether the young engineer forgets what he has learned in the very necessary sub-professional training period usually required by most industries. Regardless of the cause, the situation is one which must be solved before engineers can aspire to true professional status and the rights, privileges and unity afforded other professional groups.

About thirty years ago an engineering society (I believe in Iowa) conducted a study which indicated that out of every 100 high school graduates, four were capable of passing the standard four-year course of instruction in engineering. Of these four, the report concluded, only two were fitted by aptitude, mentality and training to practice engineering. This same study indicated that there was no reason to believe that these same four boys were able to go to college, and that in all probability many who had no aptitude for engineering were enrolled. In state-supported institutions we have long been wrestling with the problem of those who have the secondary school requirements for enrollment but do not have the aptitude for engineering. We cannot prevent a citizen of the state from registering if he presents the necessary credentials of secondary education. Thus, our classes are cluttered with many students who retard the instructor, reducing the instruction below the desired academic level and necessitating a curtailment of the desired content of the course. Even with the standards of instruction reduced below the desired level, less than 50 per cent of the average freshman class actually graduate in four or five years. This is not only an appalling waste of time and money but it also results in a large number of men falling into subprofessional positions as draftsmen, surveyors and routine chemists, who dignify their job with the title of engineer. This is a national, not a local, problem. Several years ago, a committee was formed in the Society for the Promotion of Engineering Education, with the backing of the Engineering Council for Professional Development, to investigate the possibility of securing a battery of aptitude tests which would indicate engineering talent. The committee secured funds from the Carnegie Foundation for the Advancement of Teaching, and hired Dr. E. K. Vaughn to direct the research. Ten engineering schools, distributed geographically throughout the United States, were selected as guinea pigs and the deans of these schools acted as an advisory council. Dr. Vaughn soon discovered that none of the existing tests fulfilled the requirements, so the council commissioned him to develop a new series of tests. Professors of mathematics, english, psychology, etc., were selected from the participating schools to assist Dr. Vaughn. After several years of research, experimentation and testing, the council decided that the time had come to enlarge the testing field. There are now 34 accredited engineering schools participating in this testing and guidance program. Each freshman is required to take a battery of seven tests called the "preengineering inventory." We have given these tests each quarter now for five quarters, and the results are astounding, especially when weighed against a special motivation test developed by Dr. Verner Sims of the educational psychology department at University of Alabama. Dr. Vaughn and his associates do not claim that the results of this test indicate probability of success as a professional engineer. To date, their only claim is that the tests will indicate the students' ability to pass a standard course of instruction in engineering. At Alabama we had to be sold on this battery of tests. No attempt was made to withhold the results of the tests from the faculty or students, nor were they publicized. As a result, few of the faculty had seen the test scores for the students in their classes. When the scholastic grades for the first quarter were in, I compared the academic records of the six students who had made the highest score on the preengineering inventory. Without exception, these students made straight A's in all academic work. Next, I took the six students who had the lowest inventory score and found that they had failed or made a D in every academic study. This intrigued me, so I selected a considerable number of students whose test scores were in the 50 percentile group. This group should and generally did make a C average in their academic work. There were a few exceptions, however, for example, one boy whose test score was 45, a little below average, and who, therefore, should have been doing work a little below average, was making a few B's. The results of his motivation test indicated that he had an intense desire to learn, which fact had offset his schooled and innate aptitude. Another lad whose test score was 60 had failed one subject, made a D in a second, and a C in a third course. His motivation score was low and his lack of desire to learn resulted in grades below his real ability. Dr. Sim's test on motivation has not been published as yet and therefore is not available for general use.

Today many of the larger industries are cooperating with the universities in making graduate study available to their engineers. Westinghouse, General Electric, General Motors, Chrysler Corporation, and Carnegie-Illinois Steel Corporation all have excellent arrangements whereby their employees can do graduate work in evening classes, including work for the doctor's degree. For example, the Carnegie-Illinois Steel plan permits up to 14 credits toward a master's degree to be taught by employees of the corporation who have been approved by the University of Pittsburgh. At least ten hours of work must be taken under the regular faculty of the graduate school and six credits are allowed for the thesis. The interest shown by the corporation is indicated by the fact that the industrial credits are available to the employee at practically no cost to the student. This situation is possible and practical in many industrial centers and is not necessarily a prerogative of the larger cities.

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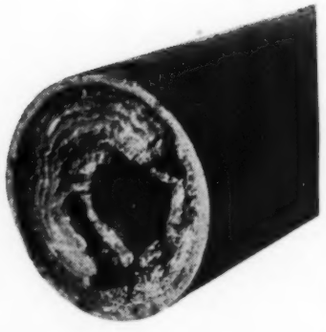
It will be of interest to you to note that the removal of the annual cost of running this booster pump will foot the total cost of cleaning these water supply lines in two years and give a more satisfactory operation in the departments requiring process water cooling."



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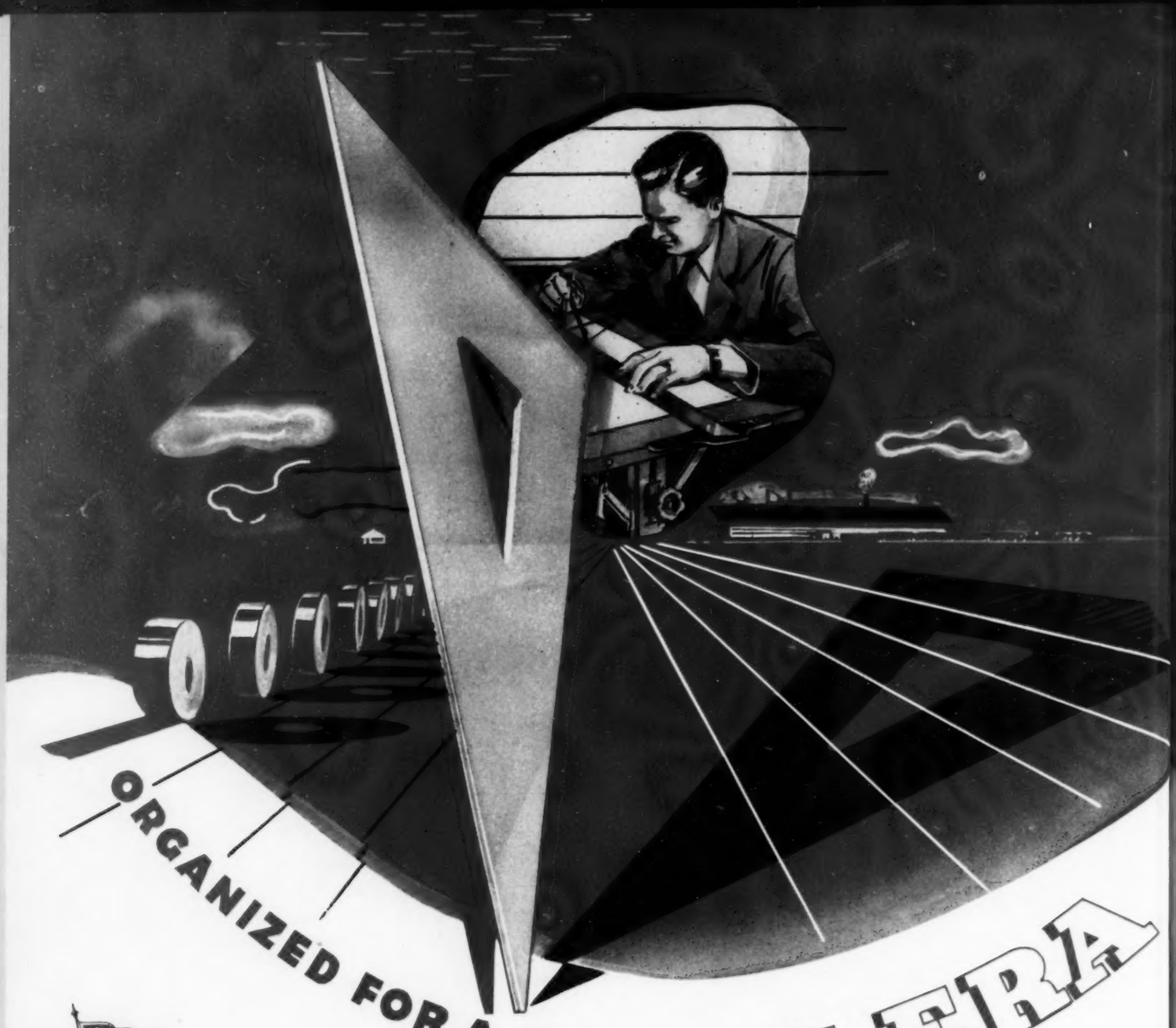

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Tomorrow's metals will be rolled and processed on modern equipment. From the minds of aggressive engineers will come the plans for future mill machinery . . . their knowledge and past experience will assure efficient operation.

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ENGINEERS AND BUILDERS OF ROLLING MILL MACHINE

NEWS SUPPLEMENT February, 1946

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Iron AND Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

## CARNEGIE-ILLINOIS STEEL CORPORATION ANNOUNCES NEW STAINLESS STEEL

▲ The first new multiple-purpose steel since the war ended was announced recently by Carnegie-Illinois Steel Corporation. Known as "Stainless 'W' " because it is a member of that family of alloy steels, the new composition belongs rather to the class of working steels and will find broad use in the industrial machines of postwar America.

This newest member of the stainless family is said to combine for the first time the high strength and corrosion resistance of standard 18-8 stainless steels with hardenability obtained through heat treatment. As a result of these three vital industrial properties, Stainless W is expected to find wide application in wrought and cast forms in the machinery field and is also available in strip, sheet, wire and tube form.

Experience with this new steel during the war, demonstrated that it can be treated successfully in standard equipment, and no difficulty is encountered through warping or dimensional changes in the course of hardening operations. It is readily fabricated, and high joint efficiencies may be achieved by spot welding, as well as with metallic arc, atomic hydrogen and heli-arc welding equipment. Machinability, as proved by shop tests, is slightly better than with austenitic 18-8 stainless steel.

Preliminary commercial applications of Stainless W indicate its usefulness where strength, hardness and corrosion resistance, all or in part, are essential, as in cams and rollers in food handling and bottling equipment. It also shows promise for application in bearings, pump valves and seats, plug valves and other parts subjected to service in food handling and bottling equipment, as well as in the oil and chemical industries. Its strength and corrosion resistance promise further advantages for structural members.

Of the chemical elements that are ingredients of the new composition, titanium is said by Carnegie-Illinois metallurgists to give it its prime distinction, the optimum proportion of this element being found in the range of 0.40 to 1 per cent. In addition to titanium, for which columbium may be substituted at will to produce precipitation hardening, and iron, Stainless W contains carbon, nitrogen, manganese, silicon, nickel, chromium and aluminum. Unlike the standard 18-8 austenitic types of stainless steel, Stainless W is magnetic.

Stainless W can be rolled into billets, bars, sheets or shapes, drawn into wire or pierced for tubing, or it may be wrought as desired to any shape or size. The finished product is unique in that it is amenable to heat treatment to develop uniformly high hardness throughout large cross sections. In addition, it possesses high resistance to most corrosive media. Results of 100-hour immersion tests in boiling copper sulphate-sulphuric acid solution, evaluated by bend tests and microscopic examination, showed this steel is not susceptible to intergranular corrosion, and three and one-half years of exposure in marine, industrial and semi-rural atmospheres demonstrated it is equivalent in corrosion resistance to the more common 18-8 types.

## PUSH-PULL TRACTOR FINDS MANY USES

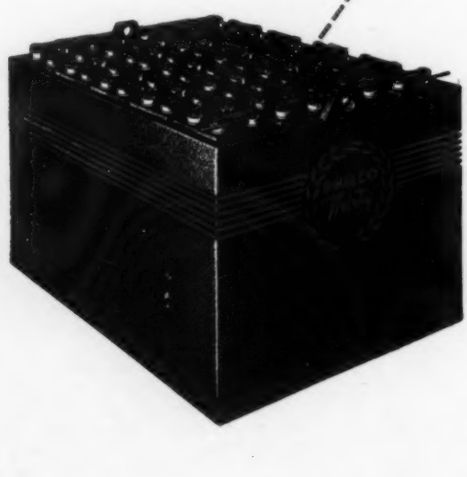
▲ The Transtractor, a new electric-propelled hand tractor developed by Automatic Transportation Company, Chicago, brings to industry the combined features of an electric-propelled hand truck and the conventional warehouse tractor. Answering industry's need for a small — but powerful — and maneuverable "push-pull" type materials mover, the Transtractor will push or pull a 6000-pound trailer load all day, or up to 20,000 poundsintermittently,dependingupon

## MOTOR MANUFACTURER ENLARGES PLANT

**More plant, rather than less, was the first requirement in the reconversion program of The Reliance Electric & Engineering Company, Cleveland manufacturer of electric motors for major industrial applications**
**Located immediately alongside the company's main plant, the new building will enclose an additional 48,000 square feet and will represent, with its machinery, equipment and moving, an expenditure of approximately $350,000.**

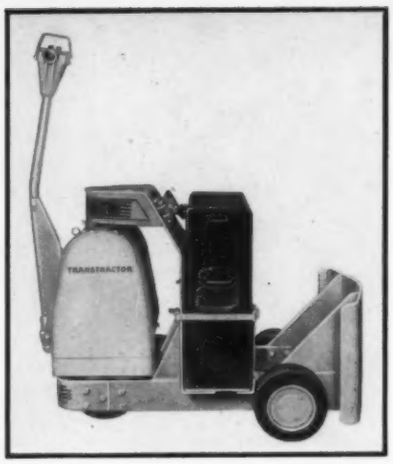
# New ways to save with PHILCO BATTERIES

Now you have palletized unit loads, and the new long-life Philco "Thirty" motive power batteries to make modern electric trucks even more useful and economical. The 30% longer life of Philco "Thirty" means substantial savings in battery replacements. Ask for Philco "Thirty" as initial equipment in your new trucks. Specify Philco "Thirty" on battery replacement orders. Write for specification data today. PHILCO CORPORATION, Storage Battery Division, Trenton 7, New Jersey.



PHILCO

FOR 50 YEARS A LEADER IN INDUSTRIAL STORAGE BATTERY DEVELOPMENT



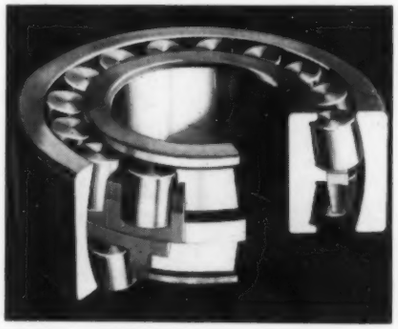
**This electric tractor is controlled through movements of the handle**

plant conditions. Finger-tip control enables one man to handle any size or type of load with facility.

The Transtractor was designed specifically for applications — in factories, warehouses, transportation terminals and storage plants, requiring a towing type unit but demanding smaller and more maneuverable equipment than standard electric tractors. It is equipped with a heavy-duty bumper plate for pushing and a coupler is available for towing operations.

## BANTAM PRODUCES NEW LINE OF BEARINGS

▲ To fulfill a widespread need in many industries, the Bantam Bearings Division of the Torrington Company, South Bend 21, Indiana announces the production of a self-aligning spherical roller bearing. This is a new addition to their line of anti-friction bearings, which already includes straight roller, tapered roller, needle and ball.



This new spherical roller bearing is specifically adaptable to heavy-duty performance in a wide range of equipment. Of particular interest are the varied applications to machinery used in paper mills, steel mills, oil production, mines and quarries.

In addition to the self-aligning feature, this new self-aligning Torrington bearing offers: (1) two-directional thrust, (2) high radial capacity, (3) high thrust capacity, and (4) unit construction for easy installation.

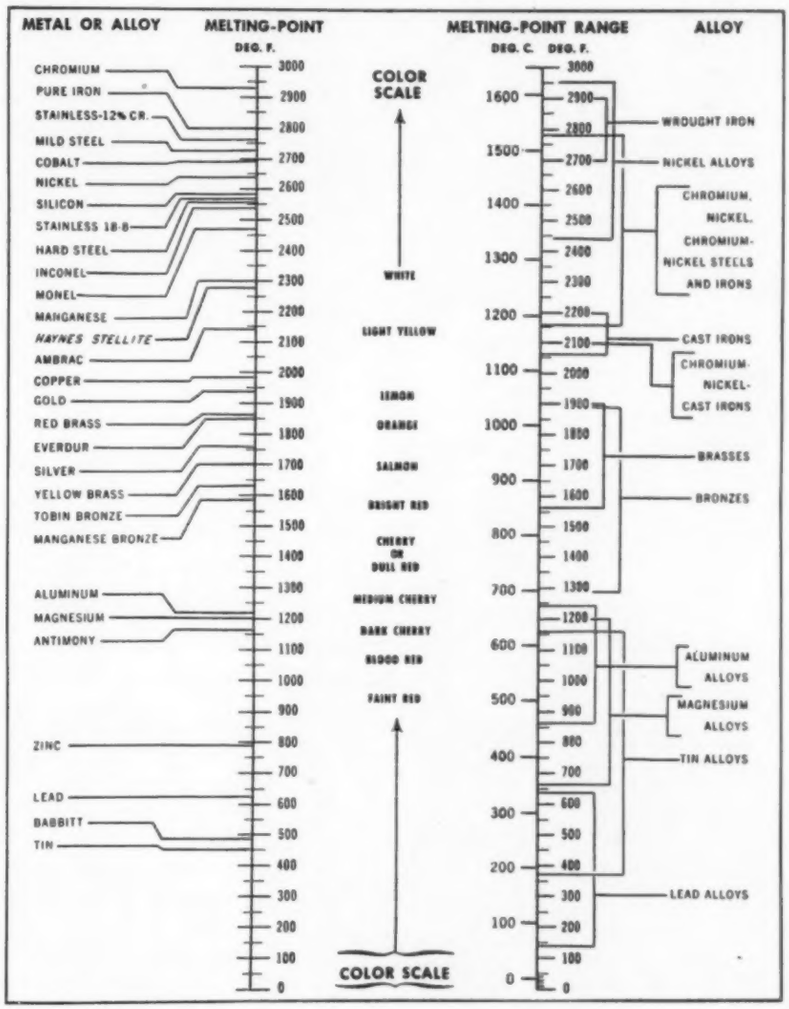
The new bearing will be produced in a full range of sizes from 1.5748 in. bore upward. It is fully described in Bulletin 100A, available by request to the Torrington Company, South Bend 21, Indiana.

## MELTING POINTS GIVEN IN CONVENIENT TABLE

▲ Linde Air Products Company, in their publication "Oxy-Acetylene Tips," presents a chart giving melting points of various metals and alloys. (See accompanying illustration.) The melting points of those metals and alloys that have a melting-point range narrow enough to be considered a single temperature are given in the left-hand column of the chart. The melting points of various alloys having a wider range appear in the right-hand column. The color scale in the center shows the approximate temperatures at which color changes appear. The right-hand column with both Centigrade and Fahrenheit scales can be used as a general conversion table between these scales.

Degrees Centigrade can be converted to degrees Fahrenheit easily by mental arithmetic. Simply multiply the Centigrade temperature by 2, subtract 10 per cent, and add 32. For example, 640 degrees C times 2 equals 1280; minus 10 per cent equals 1152; plus 32 equals 1184 degrees F. For rough estimating purposes 640 degrees C times 2 equals about 1300; minus 10 per cent equals about 1170; plus 32 equals about 1200 degrees F.

The color scale is purposely indefinite as to the border lines between the colors, because of the difference of opinion as to color names, and because the amount of light present affects the color seen. The colors for the temperatures indicated can be seen only in a dark location. In a well-lighted shop, faint red may not appear until the metal had reached a temperature of 1100 or 1150 degrees F.



# Once Again Available...
# OKONITE INSULATION

## made with wild Up-River Fine Para Rubber

Here is important news — the return of Okonite insulation — made possible because the use of natural rubber has been authorized for those severe service conditions where wires and cables are to be installed in wet locations.

Back in November, 1943, when the supply of natural rubber was withdrawn, The Okonite Company announced that it would no longer be able to provide Okonite insulation because this high-grade compound could not be made without a particular kind of natural rubber — wild Up-River Fine Para Rubber.

Now, with the gradual return of natural rubber, the latest W.P.B. rubber order recognizes that certain vitally important needs for rubber must be served first. One of these is for wires and cables operating in wet locations, an installation condition where many years of service experience have shown Okonite rubber insulation to be outstanding.

Therefore, Okonite insulation made with wild Up-River Fine Para Rubber, applied to the conductor by the Okonite strip insulating method and vulcanized in a continuous metal mold, is once again available to the electrical industry for these restricted — but most important — applications. *Okonite insulation is exactly the same compound it always was, possessing the same characteristics which years of experience have confirmed* . . . its exceptionally long life, its ability to retain tensile strength and elasticity, its high electrical values. The Okonite Company, Passaic, New Jersey.

A complete story on Okonite insulation is available in Research Bulletin 101 which includes engineering details, illustrations of methods used to safeguard performance, and records of electrical tests.

**OKONITE** SINCE 1878

**insulated wires and cables** 4401

## PRECISION GAGES ESSENTIAL ELEMENT

## IN CONTROL OF PRODUCTION ITEMS

▲ Previous to being cast into the drama of war production, an understanding of the word "precision" by hundreds of thousands of men and women was limited to the yardstick. This vast army released from the industrial front has acquired a knowledge of immense value for generations to come, namely, that of quality in its highest form through actual practice and contact with modern precision requirements.

The majority group of industrial workers, and it comprises millions, has by this time become accustomed to regard a thousandth of an inch as rough measurement because they have fought the war their own way with tenths of a thousandth. As a matter of fact, to many a housewife, former office and store clerk, the tenth of a thousandth is a form of multiplication because they speak in terms of millionths and micro inches.

The plants which have a tendency to relax on existing precision standards had better plan now to maintain that tenth of a thousandth inch accuracy and take steps to guarantee it, if they intend to survive. We are really now into a specializing age and we may expect more and more screw machine parts made in California and gears made in Philadelphia, to be fitted to other parts to complete a Massachusetts product.

These remarks all sum up to the advantages of the DoAll system of quality control, the most modern, simplified, versatile, convenient and economical development to assure maximum uniformity of quantity production or desired results of diversified setups to within an accuracy of ten millionths of an inch.

This is accomplished by means of the DoAll mobile inspection system. in other words, a modern inspection department on wheels and shrunk to the size of an automobile repairman's tool truck. The advantages in reversing the conventional procedure by bringing the inspection room to machine and man, cannot be overestimated. Quality control is in this way really approached from a modernistic angle.

It affords means for frequent checkups of all gages and the same applies to work in process by detecting fluctuations in dimensional and surface inaccuracies due to mechanical defects of production equipment.

The system enables one or two men to do work usually requiring six or more and provides such close supervision over production as to eliminate all risks of defective work. Some plants report the investment has been returned in less than six weeks in the saving of man-hours alone, and disregarding a substantial reduction in their defective work average.

As expected, a complete set of inspection quality gage blocks is the foundation of the system. The 81 gage blocks by themselves provide the inspector with more than 100,000 combinations in .0001 in., and each guaranteed through the accuracy of each block which is plus or minus .000004 in.

The innovation lies with the assortment of gage instruments which greatly amplifies the field of applications of the gage blocks. It is obvious that every gage instrument must incorporate the same accuracy as the gage blocks, or else the purpose of the system would be destroyed. One should bear in mind that any measurement produced by the various assemblies is well within a tenth of a thousandth inch accuracy, or a very few seconds of arc, as the case may be. The cost to duplicate with conventional type precision measuring tools, the combined versatility of this system, would run into thousands of dollars.

Let us consider briefly the versatility and economy of this inspection laboratory on wheels.

With two sizes of caliper blocks, four sizes of gage block holders and the set of gage blocks, internal or external snaps gages can be made in less than two minutes.

**Industry has already accepted the mobile inspection unit as post-war insurance to safeguard now existing standards of precision. The mobile inspector is in position to readily detect errors and determine whether the cause is due to material, design, machine or operator.**

With the master base block, a gage holder, one or more gage blocks and the scriber, a straight line may be drawn. Varying the gage blocks permits drawing parallel straight lines.

With the center points, correct gage block combination and gage block holder, it is possible to check leads in screw threads most accurately. Accurate arcs and circles may be drawn by replacing one of the center points with the scriber.

With the trammel points, proper gage block combination and gage block holder, one may thus check layouts with the finest degree of precision.

With the vernier gage block, having a nominal size of .700 in., it is possible to increase or decrease any dimension

**The comparator gage provides the fastest and most accurate quantity production inspection instrument available. The comparator herewith shown is however unique in design on account of its four different ranges of magnification.**

available with gage blocks in increments of .000010 in.

With the master flat, gage blocks and 5 in. sine bar, any angle within an accuracy of 2 seconds of arc can be measured.

The straight edges, of three different lengths, are of four-edges design and provide maximum life for this kind of precision tool. These straight edges will measure an accuracy of flatness within .0001 in.

Of course this is but a brief outline of the possibilities of this new inspection technique, every plant has and will discover new applications to fit most individual requirements.

A sound and easily understood gaging policy should be based on real understanding of the theory of gaging and modern manufacturing methods. The key to perfect quality control is a three-point undertaking which is greatly simplified by the use of the mobile inspection unit.

The operator works to the component tolerance, the gage maker works to the gage tolerance and the competent inspector has the facilities to measure to an accuracy that is only a fraction of the gage tolerance.

## FOSTERITE INSULATION EFFECTIVE IN MOISTURE RESISTANCE

▲ Insulation engineers have in Fosterite a new weapon for their perpetual battle against moisture. It is a synthetic material, not just one but a whole family of them of the genus alkyd-vinyl. Each, as made and applied, is a thin liquid but sets by heat into a permanent solid material that is tough and sheds water even better than the proverbial duck's back.

The need for moistureproof insulation has been recognized since the birth of the industry. World War II made a solution mandatory. Insulation on radio and radar apparatus in tropical and Pacific areas, for example, undergoes a terrific beating from temperature variation and moisture. It may be carried quickly from the boiling sun of a landing strip at a temperature of 150 degrees F to the 60-below-zero cold of a high altitude. On return to the humid air of sea level the apparatus frosts over heavily. This frost soon melts to penetrating moisture.

Most ordinary varnish-treated transformers can withstand these routine combinations of heat shock, humidity, and salt air for only a few hours, and a few days at most. Sealing the units in a metal can provides effective shielding against these enemies of insulation. But this expedient takes much more space, which might not be available in already-designed and always-crowded communication apparatus. Worse still is the doubling or tripling of the weight, intolerable on airborne apparatus.

N. C. Foster of the Westinghouse Research Laboratories applied a neat bit of reasoning to the problem. Ordinary varnishes are about 25 to 50 per cent solids carried in a volatile solvent. The varnish sets by evaporation of the solvent, leaving obviously an insulation porous by the amount of space occupied by the solvent. If, Foster reasoned, an insulation could be made without volatile solvents, there would be no voids for destructive moisture to enter. He thereupon set about in his laboratory to create just such a material, which now carries his name. In Fosterite the solvents react chemically under heat with the solids to form the solid insulation. Assuming all air has been sucked out before the Fosterite is applied, there can be no voids because nothing leaves during processing.

Fosterite is an organic insulation and has the limitations of such. Also, it is adversely affected in setting by bare copper and by certain asphalts and gums that may be present in some insulations. Hence it cannot be applied indiscriminately. Fosterite insulation, in truth, should be considered a process as well as a material. However, beyond providing a moistureproof insulation for small communication transformers it has intriguing possibilities for more familiar apparatus — possibilities the engineers frankly have not yet been able to explore. Perhaps it may prove suitable for motor stators and armatures. Certainly it has already been useful as a binder for laminated plastics. Also, oddly enough, it has served as a moistureproof filler for castings that develop blowholes or troublesome porosity.

## STEEL COMPANY OF CANADA TO REPLACE COKE OVENS

▲ The Steel Company of Canada, Ltd., Hamilton, Ontario, has awarded a contract to the Wilputte Coke Oven Corporation of New York, for the installation of 61 new Wilputte underjet high-low burner coke ovens. In addition, modernization work on the by-product and benzol plants is to be undertaken. The construction program will result in the ultimate replacement with new Wilputte Ovens of the two 40-ton Wilputte batteries which were built in 1918.

# DO YOU GET *Full Shift* BATTERY POWER

Gould Kathanode power speeds your electric truck operation throughout each working shift. There are no slow-downs due to failing battery current. No working time is lost in trips to charging room for battery changes.

In the Gould Kathanode battery *layered spun glass* mats are placed on both sides of each positive plate. After a few months of service these are actually a part of the plate itself, holding *all* useful active material in place. Thus the ability of Kathanode to deliver useful current is maintained for its entire service life.

With Gould power you get the full benefits of electric truck operation. Write Dept 42 for Catalog 100 on Gould Kathanode Glassklad Batteries for Industrial Truck and Tractor Service.

**GLASS MAT**

The extra protection of *layered spun-glass* is an original Gould development

GOULD STORAGE BATTERY CORPORATION, Depew, N. Y.

Factories: Atlanta • Boston • Chicago Dallas • Denver • Leavenworth • Los Angeles • North Bergen • Rock Island Saint Paul • Salem • Sioux City Zanesville

GOULD

GLASSKLAD CONSTRUCTION

KATHANODE

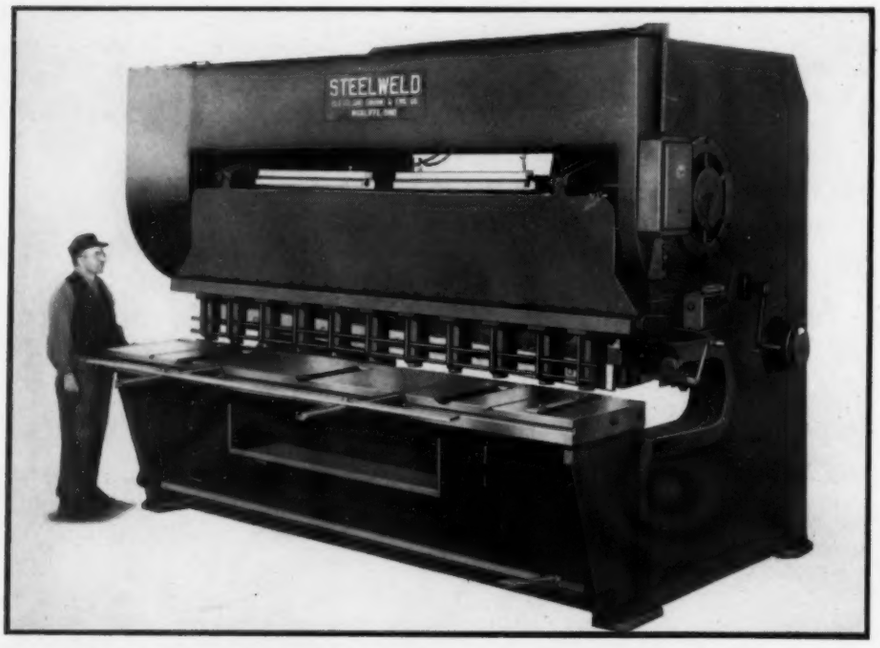
## POWER-DRIVEN METAL-CUTTING SHEARS BUILT ON NEW PRINCIPLE

▲ The heavy machinery division of The Cleveland Crane and Engineering Company, Wickliffe, Ohio, are introducing a line of power-driven metal-cutting shears that are new and radically different from all other shears now on the market. To be known as Cleveland Steelweld Shears, the new machines employ a revolutionary pivoted blade principle which makes possible several outstanding advantages and overcomes certain handicaps of present-day guillotine type shears. There are no slides or guides to wear out of true and cause inaccuracies. The upper blade operates on two heavy pivot pins secured to the end housing and travels in a circular path.

A most valuable feature is the ease with which the knife clearance may be varied to suit the thickness of plate being cut. Turning a hand crank, conveniently located on the right end housing, changes the gap between the knives. A large dial indicator indicates the clearance in thousandths of an inch and also shows the plate thickness that may be cut for any knife setting.

Steelweld Shears may be readily arranged for squaring, slitting, or set at any intermediate position for notching, and firmly locked. This feature is included on all machines with standard 24-inch deep throats, but is not furnished on the smallest size, where the throat depth is 18 inches.

Steelweld Shears have been developed in various sizes for cutting plate of all thicknesses from 12 gauge to 1¼ inch and for lengths from 6 ft to 16 ft. Speeds range from 60 strokes per minute on the smaller shears to 25 strokes per minute on the largest size.




**Machine illustrated is Model No. 610 which cuts plate up to three-fourths of an inch thick and ten feet wide.**

## POWER TRUCK HAS NON-SWIVEL TYPE BOOM

▲ One of the simplest, speediest and most economical methods of lifting and transporting many types of loads in manufacturing operations is by means of a power truck equipped with a horizontal, non-swivel type boom, moving vertically with its shoulder riding in the upright columns of the truck.

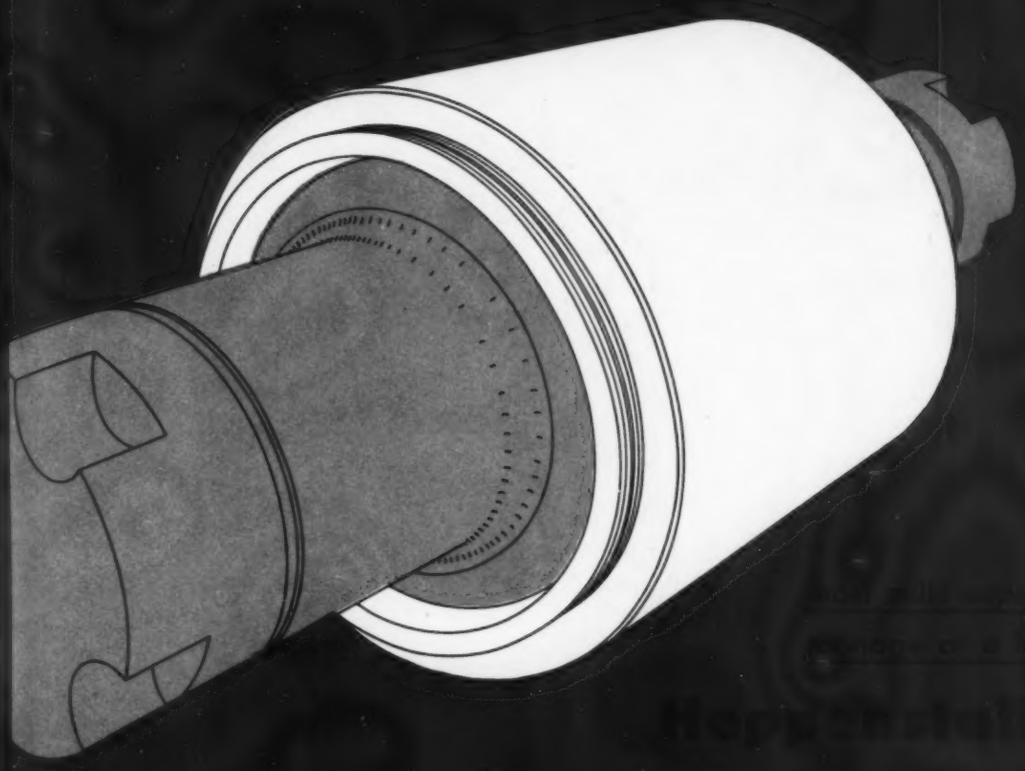
This mechanism has proved particularly useful for single, heavy and bulky objects to which a hook, chain, rope or cable may be attached. No muscle-power is required beyond securing a chain or cable to the object and to the hook on the boom. The boom functions somewhat as a boom on a crane, but the complete unit is more compact and can be maneuvered within more limited areas.

**Power truck with boom is particularly useful for handling single, heavy or bulky objects.**

The truck as developed by The Elwell-Parker Electric Company, Cleveland, can carry loads up to 3000 pounds. The boom is available in lengths of 72, 66 and 60 inches, from face of uprights. At lowest point the hook is 22 inches above floor level; at highest, 8 feet. The boom may be made interchangeable with a platform whereby a still greater variety of loads may be transported.

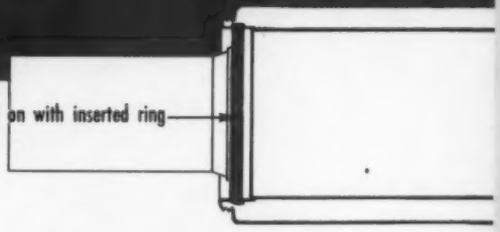
## STUDENT WELDING PAPER CONTEST ANNOUNCED

▲ To stimulate undergraduate interest in welding, funds have been donated by A. F. Davis, of the Lincoln Electric Company, for the A. F. Davis undergraduate welding award, which will consist of four cash prizes totaling $700 to be presented annually to authors and publications for the best and second best articles on welding published in undergraduate magazines or papers during the preceding year. Any undergraduate of a college, university, or institute of technology in the United States or Canada is eligible, but the paper must be published in an undergraduate publication. Judges selected by the educational committee of the American Welding Society will select the winning paper in July of each year on the basis of originality of the paper and thoroughness in which the subject is covered. The awards will be as follows: $200 each to the author of the best paper and to the publication in which it appears, and $150 each to the author and the publication for the second best paper.



# Heppenstall Sleeves

## for back-up rolls




Heppenstall back-up roll sleeves have 3 important, proved advantages over a solid roll: (1) They last much longer; (2) They cost less; (3) They eliminate the expense of scrapping a worn roll . . . Being a relatively small mass of metal with no necessity for the usual compromise between strength of necks and hardness of surface, these sleeves permit the incorporation of all Heppenstall's skill in metallurgy, forging and heat treating . . . and they can be furnished in any workable degree of hardness desired. Write for the complete story. Address Heppenstall Co., Pittsburgh, Pa.

**Heppenstall**

*the most dependable name in forgings*

# From Bosh Plates to Monkeys

**Mantle Plates**

**Tuyeres**

**Tuyere Coolers**

**Stack Plates**

**Valves**

**Valve Seats**

**Valve Plugs**

**Cinder Notch Coolers**

*Specify*

**N • B • M**

**BRONZE AND COPPER CASTINGS**

**Improved alloys and automatic pyrometer controlled pouring techniques give them increased stamina and longer life.**

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**NATIONAL BEARING**

**DIVISION**

ST. LOUIS • PITTSBURGH

AMERICAN Brake Shoe COMPANY

PLANTS IN: ST. LOUIS, MO. • PITTSBURGH, PA. • MEADVILLE, PA. • JERSEY CITY, N. J. • PORTSMOUTH, VA. • ST. PAUL, MINN. • CHICAGO, ILL.

## METAL ALLOY SHOWS OWN TEMPERATURE

▲ The gas turbine, powerful combustion engine which since development has refused to have its temperature taken, has been forced literally to take its own temperature by General Electric engineers through use of a special metal alloy which tells temperature by color.

The alloy, a chrome cobalt composition, shows a marked color change for every 25 degree change in temperature from 500 C to 700 C, then reverts back to its original color and begins the color scale over again in a higher range of from 725 C to 900 C (1652 F). This is believed to be the highest temperature ever recorded accurately inside a gas turbine.

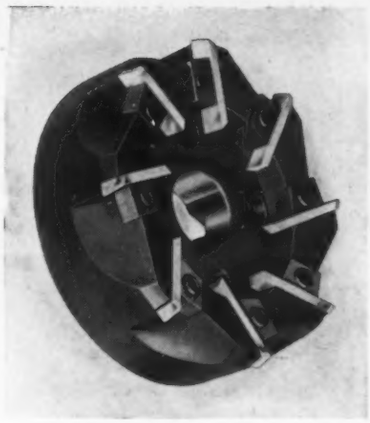
By making turbine parts of the alloy, the turbine has no alternative but to take its own temperature. Following operation, the turbine has to "show its colors," and by doing so also has to show its temperatures reached during operation, according to the engineers.

On the basis of one hour heat treatment, the alloy at 500 C turns a light straw color, at 525 C, a straw color, at 550 C a bronze color, at 575 C purple, at 600 C dark blue, etc. The alloy turns light blue at 700 C, and according to all precedent, it next should turn grey, indicating the end of the color scale. Instead of turning grey however, the alloy at 725 C reverts back to a light straw color and begins the progression of colors over again. The alloy turns light blue in the second scale when it reaches 900 degrees and begins to show greying tendencies at 925, the engineers report.

## MILLING CUTTER HAS UNIQUE FEATURES

▲ Kennametal, Inc., of Latrobe, Pennsylvania, has developed a new type of Milling Cutter, called the "Universal" face Kennamill, which consists of a precision built heat treated steel body, or tool holder, with a set of detachable solid Kennametal blades (as many as there are inches in the cutter diameter) mechanically held in position.

Five standard sizes are now available, 4 in., 6 in., 8 in., 10 in., and 12 in., diameter. Blades for these are of the same cross section, and when



shortened by regrinding, can be used in smaller cutters successively. They are "formed" at both ends, and can be used in either right or left hand cutters.

The face mill can be adapted for milling different materials simply by interchanging blades. Those having the proper grade of carbide and suitable cutting angles are selected and inserted.

## PLANT EXPANSION TO BE COMPLETED THIS YEAR

▲ Installation of $500,000 in new manufacturing, processing and development equipment, started in 1945 will be completed this year, according to Henry F. Dever, president of Brown Instrument Company, Philadelphia industrial instrument division of Minneapolis-Honeywell Regulator Company.

During the past year the company acquired and installed $250,000 in new and modern machine tool equipment, constituting part of the recently announced overall expansion plan of the entire Honeywell organization. The Philadelphia division will retain additional branch sites, acquired during war years, it was added, and will make other organizational changes for greater worker comfort and operational efficiency.

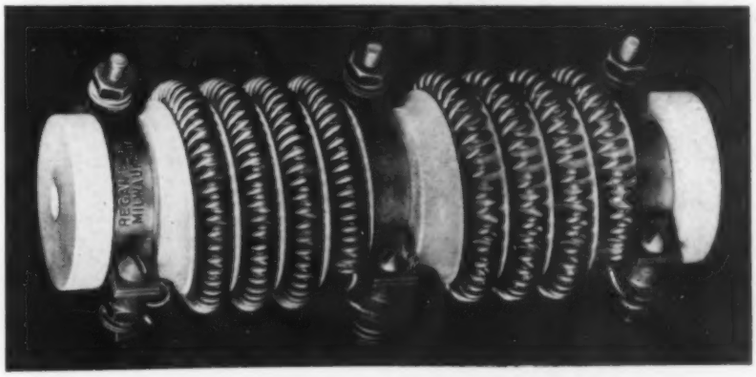
## CENTER TAP RESISTOR GIVES NON-HEATING CONNECTION

▲ Techtmann Industries, Inc., 828 N. Broadway, Milwaukee 2, Wisconsin, national distributors for Regan Electrical Products, bring to the attention of electrical engineers the new type CAM center-tap resistor developed by the Regan Engineering Corporation.

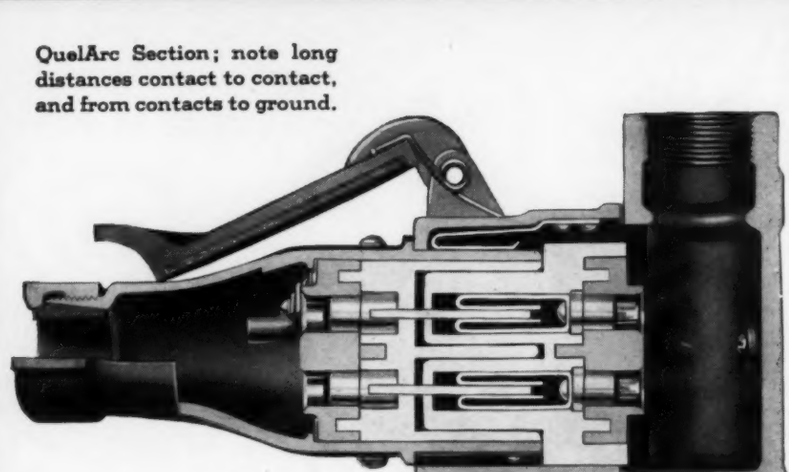
The resistor consists of a core, machined from a solid piece of steatite, upon which is wound a helical resistance wire element. Center and end taps are half-straps securely clamped to the core, assuring absolute mechanical rigidity independent of support by the resistance element. The finest wire can be tapped off with positive assurance of a good non-heating connection.

The tap assembly employs brass nuts and bolts and stainless steel lock washers. All parts are zinc plated. Protection against fungus growths is provided by an additional chromate dip plating.

The CAM resistor is designed on the same principle as the Regan AVW and NC types, which have found such wide acceptance in the electrical field. Should a unit be overloaded and burn out, the coil can be removed and replaced in a few minutes by removing two nuts. Connections or supporting assembly need not be disturbed.



QuelArc Section; note long distances contact to contact, and from contacts to ground.



# QUELARC circuit breaking plugs and receptacles

BUILT FOR MILL SERVICE

The QuelArc line of circuit breaking plugs and receptacles—ratings up to 200 amperes—is built to stand up in mill service, delivering dependable service with minimum maintenance. The exclusive QuelArc construction provides exceptional protection to the contacts, for safe use as current rupturing devices with heavy duty portable electrical equipment.

In the QuelArc design, note the complete enclosure of all contacts in insulating chambers, which form an arc-trapping space. Note also the long distances from contact to contact and from contacts to ground. Contacts are individually renewable and full ground protection is provided.

QuelArc plugs and receptacles are available in a complete line, 2, 3, 4 wire types; ratings 20, 30, 60, 100 and 200 amperes. Many other types of Pyle-National plugs and receptacles are available for portable tools, control and instrument circuits. Consult your Pylet catalog for complete listings.

**THE PYLE-NATIONAL COMPANY**

**1334-58 North Kostner Avenue • Chicago 51, Illinois**

Offices: New York • Baltimore • Pittsburgh • St. Louis
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RAILWAY ELECTRICAL EQUIPMENT
• SINCE 1897 •

HEADLIGHTS • TURBO-GENERATORS • CONDUIT FITTINGS • FLOODLIGHTS • MULTI-VENT

## PINIONS EASILY PULLED BY NEW DEVICE

▲ The exclusive design of the Klay puller, in which the pulling and gripping actions are independent of each other, is claimed to develop greater pulling power plus a safer and more positive grip on the object being pulled. In addition to many other uses around steel mills, Klay pullers are extensively used for pulling pinions and couplings on hot strip mills.

Not only does the Klay lock nut principle securely lock the hooks to the gear or wheel so that they will not slip off, but the grip is equally applied on all sides. Thus, it is said, the total force developed by the Klay pulling screw is directed toward removing the wheel instead of part of its being diverted into gripping power.

Klay pullers are made in two- and three-hook types for pulling anything from a 5/8 in. gear up to a 40 in. wheel or hub. Detailed information on Klay pullers can be had by writing the manufacturer — The Scott and Ewing Company, Dept. N-4, Findlay, Ohio.

## SOLVENT SAFETY SAVES MONEY AND LIVES

▲ Organic solvents, which are among the most widely used industrial chemicals, can be dangerous to health unless workmen are protected from inhalation of the solvent vapors and prolonged skin contact with the liquids. The control of these hazards, in addition to its humanitarian value, pays sizable dividends in dollars and cents.

Loss of solvent is avoided by controls which are designed primarily to protect health through minimizing the evaporation of volatile liquids. One of the chlorinated solvents, for instance, evaporates at the rate of about ¼-gallon a day per sq ft of liquid surface exposed to a room temperature of about 70 F. When solvents are handled in closed systems, isolated from the workroom atmosphere, losses of this kind are wiped out while health protection is assured. If it is necessary to use solvents in the open, specially designed work procedures and operating equipment will prevent vapors from escaping into the air, simultaneously preventing illness among workers and conserving valuable chemicals.

Poor control of organic solvents can result in a variety of health disorders. These chemicals are a frequent cause of dermatitis, one of the most common industrial diseases and one of the most economically serious.

Even moderate exposure to solvent vapors over a period of time may cause nervousness, irritability, excitability, dizziness, weakness, depression, lethargy, defects in vision, and impairment of the powers of judgment and coordination.

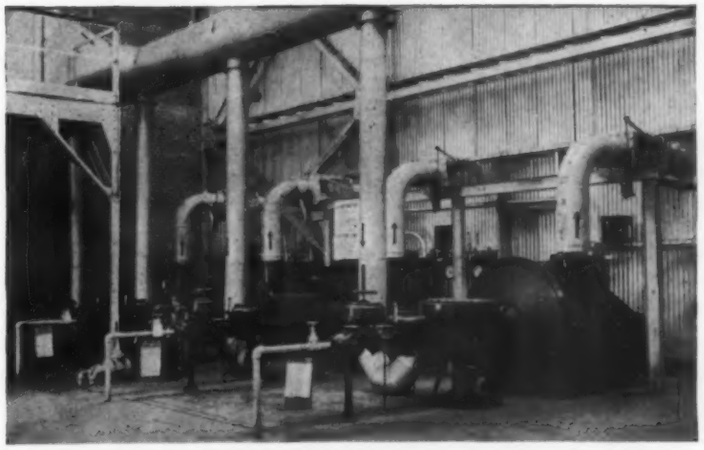
Partial or total disability, due to disorders of the liver, kidneys, blood, or nervous system, may result from prolonged or repeated exposures to excessive amounts of vapor. Every such case of systemic illness means a serious loss of time and money.

An adequate solvent safety program, in addition to being an important factor in decreasing solvent loss, increasing efficiency, and improving labor relations, diminishes compensation payments and helps cut the cost of compensation insurance.


*Efficient Control of COMBUSTION RATIOS*

**for all types of industrial combustion and heat treating is assured by using**

**KEMP INDUSTRIAL CARBURETORS**



**The KEMP INDUSTRIAL CARBURETOR functions perfectly, completely pre-mixing gas and air in pre-determined ratios.**

**The KEMP INDUSTRIAL CARBURETOR**

**makes possible hitherto unheard of accuracy of control in heating efficiencies and types of application.**

●

***Ask for Bulletins IC-020 and IC-021***

●

**THE C. M. KEMP Manufacturing Co.**
**OF BALTIMORE**

**405 E. OLIVER ST. BALTIMORE 2, MD.**

# 5-POINT PROGRAM

## for Eliminating Wire-Failures in Control, Power and Lighting Circuits exposed to Severe Operating Conditions

1. **National Electrical Code Type AVA** (max. operating temperature 230° F.) Rockbestos A.V.C. 600 Volt Boiler Room Wire in sizes No. 18 to 4/0 AWG. For lighting and control circuits around boilers, furnaces, steel mills, etc., and resistor wiring.
2. **National Electrical Code Type AVB** (max. operating temperature 194° F.) Rockbestos A.V.C. 600 Volt Switchboard Wire in sizes No. 18 to 4/0 AWG. For fireproof switchboard wiring. Takes right angle bends without cracking braid. Rockbestos A.V.C. Hinge Cable and Bus Cable also available.
3. **National Electrical Code Type AVA** (max. operating temperature 230° F.) Rockbestos A.V.C. 600 Volt Flexible Motor Lead Cable in sizes No. 18 AWG to 1,000,000 CM. For coil connections, motor and transformer leads exposed to heat and moisture, oil, grease and fire hazard.
4. **National Electrical Code Type AVA** (max. operating temperature 230° F.) Rockbestos A.V.C. 600 Volt Power Cable in sizes No. 18 AWG to 2,000,000 CM. For power circuits and hot-spot wiring in generating and industrial plants.
5. Rockbestos A.V.C. 600 Volt Multi-Conductor Control Cable in standard sizes, No. 12—19/#25 and No. 9—19/#22 (other strandings on order) with from two to nineteen conductors insulated the same as Rockbestos A.V.C. Power Cable except braids on individuals which are coded cotton.

Don't let tough conditions cause wire-failures that tie up equipment, slow down production and bump up maintenance expense . . . install *failure-preventing* Rockbestos A.V.C. in the trouble spots.

These National Electrical Code type *permanently insulated* Rockbestos developed wires are insulated with the time-tested combination of lubricated varnished cambric and *impregnated felted asbestos* that stands up under high ambient temperatures and conductor-heating overloads without baking brittle or flowing . . . without cracking under vibration . . . without rotting or swelling in contact with oil, grease or fumes . . . and without burning when exposed to flame.

Rockbestos A.V.C. has ample moisture resistance for conduit installations — and for dry high-temperature applications there are many other *permanently insulated* Rockbestos All-Asbestos (N. E. Code Types) wires, cables and cords in our line of 125 different standard constructions. Specify them for long and dependable service under severe conditions in boiler rooms, steel mills, steam tunnels, power plants . . . and around furnaces, kilns, lehrs, steam lines, ovens or other hot spots.

For a catalog, samples or recommendations write nearest district office or:

**Rockbestos Products Corporation, 121 Nicoll Street**
**New Haven 4, Connecticut**

# ROCKBESTOS A.V.C.

## The Wire with Permanent Insulation

NEW YORK, BUFFALO, CLEVELAND, CHICAGO, PITTSBURGH, ST. LOUIS, LOS ANGELES, SAN FRANCISCO, SEATTLE, PORTLAND, ORE.

## SELF-LUBRICATING VALVE REDUCES STICKING

▲ The gasoline metering valve typifies the advantages of all Morganite self-lubricating valves and slides. This particular valve replaced a similar part of conventional material. In actual tests, over an 18 months period, it effected a reduction of almost 90 per cent in operating impairments caused by friction, gumming, sticking, etc. Currently, applications of Morganite valves and slides include practically every type of liquid, gas or viscuous installation.

Products are manufactured by Morganite Brush Company, 3304 Forty-eighth Avenue, Long Island City 1, New York.

## HAYS ADDS COCHRANE METERS TO THEIR LINE

▲ The Hays Corporation, Michigan City, Indiana, manufacturers of boiler room and industrial instruments and controllers, announced that, effective January 1, Cochrane flow meters, formerly manufactured by The Cochrane Corporation of Philadelphia, became a part of the Hays line of products and will be sold by Hays representatives as Hays-Cochrane instruments for flow, liquid level, pressure and temperature measurement.

The flow meters will continue to be manufactured in Philadelphia by The Penn Industrial Instrument Corporation, an organization comprised of the same men who have been responsible for the production of these meters for many years.

The addition of flow meters to the Hays line will round out their line of draft gages, combustion meters, flue gas analyzers and automatic combustion controllers, giving the user the advantage of obtaining all of these boiler room and industrial process instruments and controllers from a single source.

Mr. Daniel Meyer and Mr. Fred Skirving, who have been associated with the instrument division of Cochrane Corporation for a number of years, have joined the Hays engineering staff at Michigan City and will specialize on flow meters and flow measuring problems.

The Hays Corporation also announces the Hays Veriflow Meter for measuring, indicating, and totalizing various liquids used in industry. The outstanding feature of the new meter is its ability to indicate the rate of flow at a point remote from where the meter is installed. This is in addition to the rate of flow indication and integrator which are integral with the meter itself. To secure the remote indication the generator is mounted on top of the flow meter, the same shaft operating both the generator and the totalizing register. No external source of electricity is required because the indicating meter measures the output of the generator and is calibrated to indicate the corresponding rate of liquid flow through the meter. The scale of the indicator can be calibrated to read in any values of flow desired such as gallons per minute.

## CANADIAN STEEL COMPANY SOLD TO AMERICAN FIRM

▲ Wm. B. Given, Jr., president of American Brake Shoe Company, announced the purchase of Joliette Steel Limited, one of the largest producers of manganese and alloy steel castings in Canada. The company will be operated by the present management working under the direction of Brake Shoe's American Manganese Steel Division. Joseph B. Terbell will head the company, and J. L. Mullin will be a vice president.

Brake Shoe has planned an expansion and mechanization program for Joliette Steel Limited. Production will be increased and a wider range of alloy steel products produced. Amsco products such as manganese dredge buckets, dippers, frogs and switches, crusher parts and mill liners will now be produced in Canada plus many other alloy steel castings for construction, mining and general industrial applications. All steel castings will carry the trademark and guarantee of Joliette Steel Limited and Amsco.

## LUBRICANT COMPANY HOLDS ANNIVERSARY

▲ With 1946 — Non-Fluid Oil marks fifty years of service to industry — beginning April 21, 1896.

Fortunately, the New York and New Jersey Lubricant Company has no reconversion problem, all its energies having been concentrated on getting top production of Non-Fluid Oil for the war effort — to speed manufacture of guns, planes, ships, tanks, trucks, tires, tents, uniforms and scores of other items. War needs called for certain improvements in Non-Fluid Oil which enable it now, more than ever, to provide better lubrication at less cost per month.

## REGULATOR RAISES POWER FACTOR

▲ The Haug System power factor regulator is announced by the Modern Control Equipment Company, 176 W. Adams Street, Chicago. Connected to the lines of commercial power users, the makers state that it will raise the power factor by taking the magnetizing current off the line with a negligible cost in operation, that, by increasing the power factor, it will greatly reduce the monthly power bill . . . will increase low voltage to

desired value where voltage was previously low due to poor power factor. Reactors and transformers are of dry type construction. No fireproof enclosures are necessary. The regulator requires no discharge coils or other safety devices, and is made under A. I. E. E. specifications and N. E. M. A. standards.

# New Literature

▲ Case hardening in Surface Combustion standard rated furnaces is described in a new 4-page bulletin, No. SC-127 issued by Surface Combustion Corporation, Toledo 1, Ohio. Application of pack, liquid and gas carburizing is covered and the ideal types of furnaces for the various methods are shown, together with illustrations of case-hardened steel parts and actual furnace installations. A table of pot recommendations, including pot materials, maximum bath temperatures, and type and composition of salt baths is included.

▲ International Nickel Company, Inc. revised list "A" of current publications on nickel alloy steels, nickel cast irons, nickel brass and bronzes, and nickel plating is now available. Publications offered cover the production, fabrication, properties and uses of nickel alloys for industrial applications, and the production, properties and use of nickel electrodeposits.

▲ The new EC&M bulletin 902 on type CSM (Cold Strip Mill) Coil-Handling Magnets, has recently been issued by The Electric Controller & Manufacturing Company. In this new literature, details of construction, lifting-capacities, weights, and current requirements are included to present a complete story. For tin mill service, a similar design magnet has been developed. Tin mill coils are usually narrower, but have a greater wall thickness due to a greater number of turns. The magnet for this service is therefore wider and has longer pole shoes to span the thicker wall of the coil.

▲ The Foxboro Company, Foxboro, Massachusetts, has issued catalog 370, presenting the company's full line of recording and indicating instruments for measurement and control. Arranged for quick reference, and profusely illustrated, the sections deal with instruments for temperature applications, pressure, humidity, flow, liquid level, density, and other process variables. Control valves, planimeters, instrument accessories and supplies are included.

This catalog is the first in which Foxboro has been able to show its line of Dynalog electronic instruments, the sale and use of which has, until recently, been limited to military applications. A complete list of The Foxboro Company's branches in North America and of its overseas representatives is given. Copies will be sent on request.

▲ Recently issued by Electric Machinery Manufacturing Company is a 4-page folder No. FF-11 which illustrates and describes eight of the economies and operating advantages gained by use of synchronous motors engineered to large, constant-speed industrial applications. The folder gives examples of synchronous motors direct-connected to various types of drives. Copies may be obtained by writing the manufacturer at Minneapolis 13, Minnesota.

▲ "DC Mold Release Fluid and DC 7 Compound" is a booklet which describes the use of two silicone products, DC mold release fluid and DC 7 compound, by the rubber and plastics industry. These silicone mold release agents serve as lubricants which reduce the friction between dies and plastic materials, improve plastic flow, reduce surface striation, and afford easy release from the mold or from rubber bags used in low pressure laminating.

▲ Man's age-long struggle with friction, beginning with the discovery of prehistoric man that it was easier to roll a log than to drag it, and concluding with lubrication recommendations for all types of modern machinery, is the subject of a book just published by the Alemite Division of Stewart-Warner Corporation, Chicago. Entitled "Alemite Answers," it is a graphic presentation, with illustrations of hydrocarbons cavorting in animated-movie style and cutaway views, of bearings and other friction points to demonstrate in laymen's pictures and terms, the how, what, when, where and why of lubrication. The book is for distribution at three dollars per copy through the Alemite distributor organization, to industry and the automotive, marine and aviation fields.

▲ The revised edition of "Standard Methods of Analysis," a publication which in the past has met with considerable demand, has now been produced in a new standard format.

The cost of the book is 7/6d net, and copies may be obtained on application to the Publications Department, The United Steel Companies Limited, 17 Westbourne Road, Sheffield 10, England.

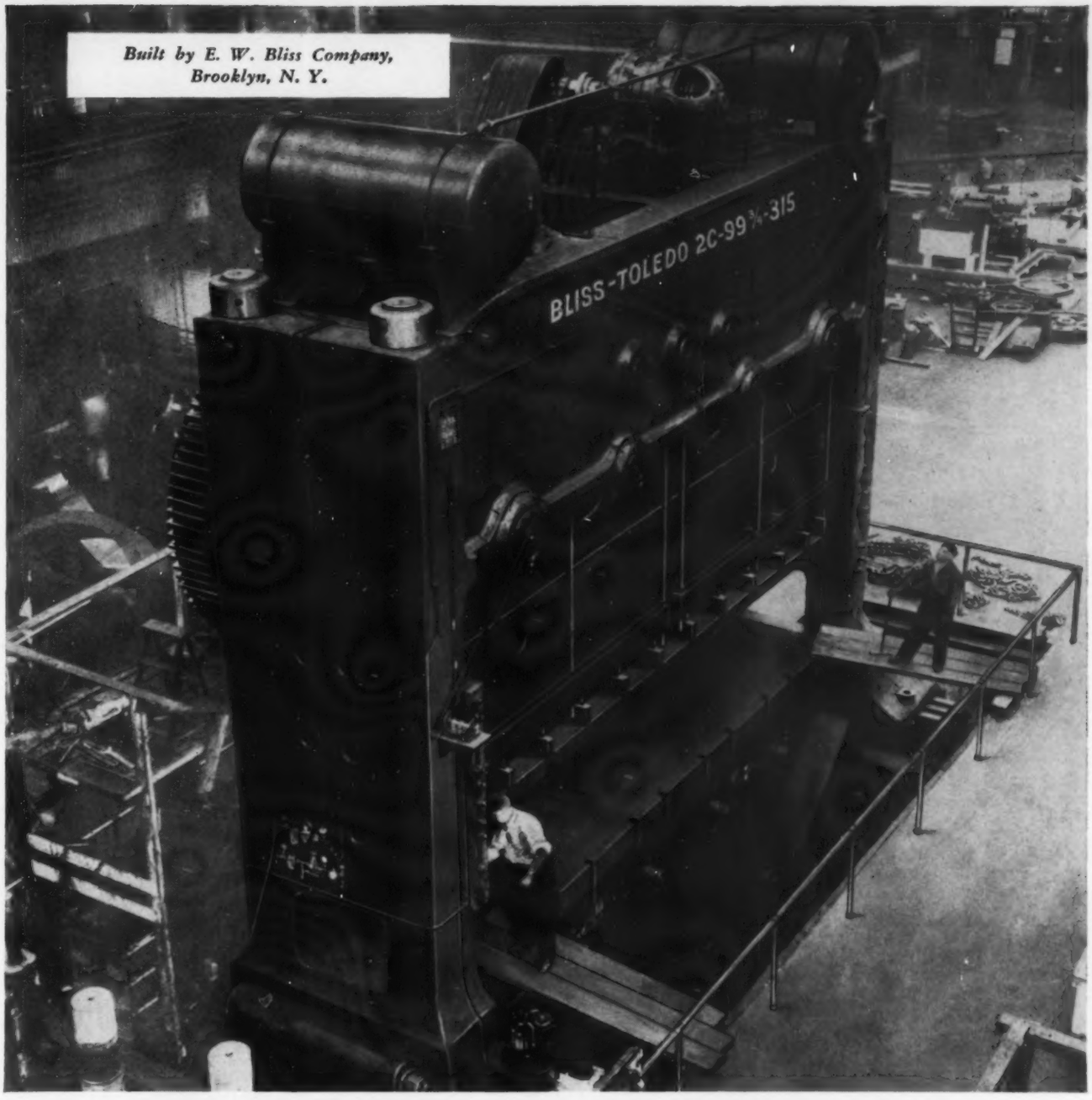
▲ Storage batteries for stationary applications are featured in Catalog No. 1000 recently published by Gould. In this booklet details and illustrations of the three types of Gould batteries available are discussed. Various characteristic discharge curves are shown and technical data is furnished covering all sizes and types used in stationary applications. Copies may be obtained from the Gould Storage Battery Corporation, Depew, New York.

▲ A 16-page bulletin No. 11-B, recently published by Ajax Electrothermic Corporation, Trenton 5, New Jersey, describes high-speed precision melting of alloy steels and other ferrous metals in Ajax-Northrup induction furnaces. Furnaces in sizes from 120 lb to several tons capacity, powered by efficient motor generator units from 50 kw up are illustrated and fully described. Smaller furnaces are covered in other bulletins. Of particular value are helpful hints in planning an efficient shop, and a table showing proper equipment to maintain any given production schedule.

▲ The Drever Company has just released a new bulletin B-51 containing all the facts about the Drever Ammonia Dissociator, which produces low cost protective furnace atmospheres for such processes as bright annealing, clean hardening, brazing, and sintering powdered metal parts.

A complete section of Bulletin B-51 covering the Drever Ammonia Dissociator Equipment will be sent on request to the Drever Company, 783 E. Venango Street, Philadelphia 34, Pennsylvania.

▲ Eccles & Davies Machinery Company, Inc., Los Angeles, California, has issued a 16-page two-color booklet "Edco Electrodes" which describes in detail the physical and chemical properties of these time-tested phosphor bronze electric welding rods. It gives uses and techniques for welding copper, bronze, cast iron, steel and their alloys; and contains a polarity table and directions for best welding results. The information will prove valuable to every welder and shop man. Copies are available by writing the Welding Division at the above address.




# 2,500 TONS AT A STROKE!
## With TIMKEN BEARINGS Carrying the Power!

This Bliss-Toledo single action, straight side, mechanical press is one of the largest ever built. It weighs 1,150,000 pounds and can exert a pressure of 2,500 tons at the end of the stroke.

The press was designed primarily to blank out chassis frames and produces two frames every ten seconds, operating at 6 strokes per minute.

To help make its work easier and more accurate; to increase its endurance; and decrease maintenance; Timken Tapered Roller Bearings are applied on the drive shaft and flywheel, clutch and brake, where they eliminate friction, prevent wear, carry radial, thrust and combined loads and hold shafts and gears in correct and constant alignment.

This big press was built for the Russian Government and already has been shipped. It will be used in connection with the Russian reconversion and rehabilitation program. The Timken Roller Bearing Company, Canton 6, Ohio.

P.S. No matter what kind of equipment you are building, it will pay you to make sure the trade-mark "TIMKEN" is stamped on every bearing you use.

▲ A voluntary simplified practice recommendation for structural steel shapes has been approved for promulgation, according to an announcement of the division of Simplified Practice of the National Bureau of Standards. Effective February 15, 1946, and identified as "R216-46, Hot-Rolled Carbon Steel Structural Shapes," the recommendation will be available in printed form, from the office of the Superintendent of Documents, Government Printing Office, Washington 25, D. C., early in February, for 10 cents each. A discount of 25 per cent will be granted on orders for 100 or more copies.

The recommendation, which had its beginning in a proposal of the technical committee on Carbon Steel Plate and Structural Shapes, of the American Iron and Steel Institute, is composed of 19 tables and covers the nominal sizes, and weights per linear foot of wide-flange sections, light beams, stanchions, joists, standard-beams, H-beams, wide-flange bearing piles, channels, and tees, with angles being shown in thicknesses. Sections and angles used in carbuilding and shipbuilding are also included.

▲ A new catalog section on its lines of hose fittings, including couplings, joints, clamps, washers, nozzles, nipples and flanges has been published by The B. F. Goodrich Company, Akron, Ohio and is available upon request. Featured are instructions for properly attaching couplings, and other types of fittings which add to service life and make the hose safer.

▲ NEMA has recently published a revised edition of the "Specialty Transformer Standards," publication No. 45-98, which supersedes publication No. 38-52. The revised publication contains standards for the following types of transformers: general-purpose, control, high-reactance control, signalling, ignition, and doorbell transformers. It also contains the American Standard "Lead Markings and Terminal Connections for Constant-potential Transformers," and definitions of the terms used throughout the publication.

NEMA has also announced the publication of the following standard: "NEMA Standard for Color Markings for Electrode Identification," publication No. 45-108. One folder, 8×10½, 10c. This standard covers the identification by color of the different types of end and center-grip welding electrodes. The chart supersedes the one formerly included in publication No. 42-81 and has now been revised and issued separately as a supplement to the revised "NEMA Electric Arc-Welding Machine and Electrode Standards," publication No. 45-105.

▲ A booklet, "Symposium on Magnetic Particle Testing," comprising eight technical papers with discussion, which was presented at a meeting of the Philadelphia district, American Society for Testing Materials was recently published. This publication covers the application of this widely used test in a number of industries. Each of those participating in the symposium is an outstanding authority in this field and is in close touch with the applications of magnetic particle testing and the interpretation of results.

Copies of this 130-page book, 6×9 in. page size, heavy paper cover, can be obtained from A.S.T.M. Headquarters, 260 South Broad Street, Philadelphia 2, Pennsylvania, at $1.25 each.

**No other one instrument**

**PERFORMS ALL THESE FUNCTIONS**

INDICATE AIRFLOW

INDICATE FUEL FLOW

SHOW RATIO OF AIRFLOW and FUEL FLOW

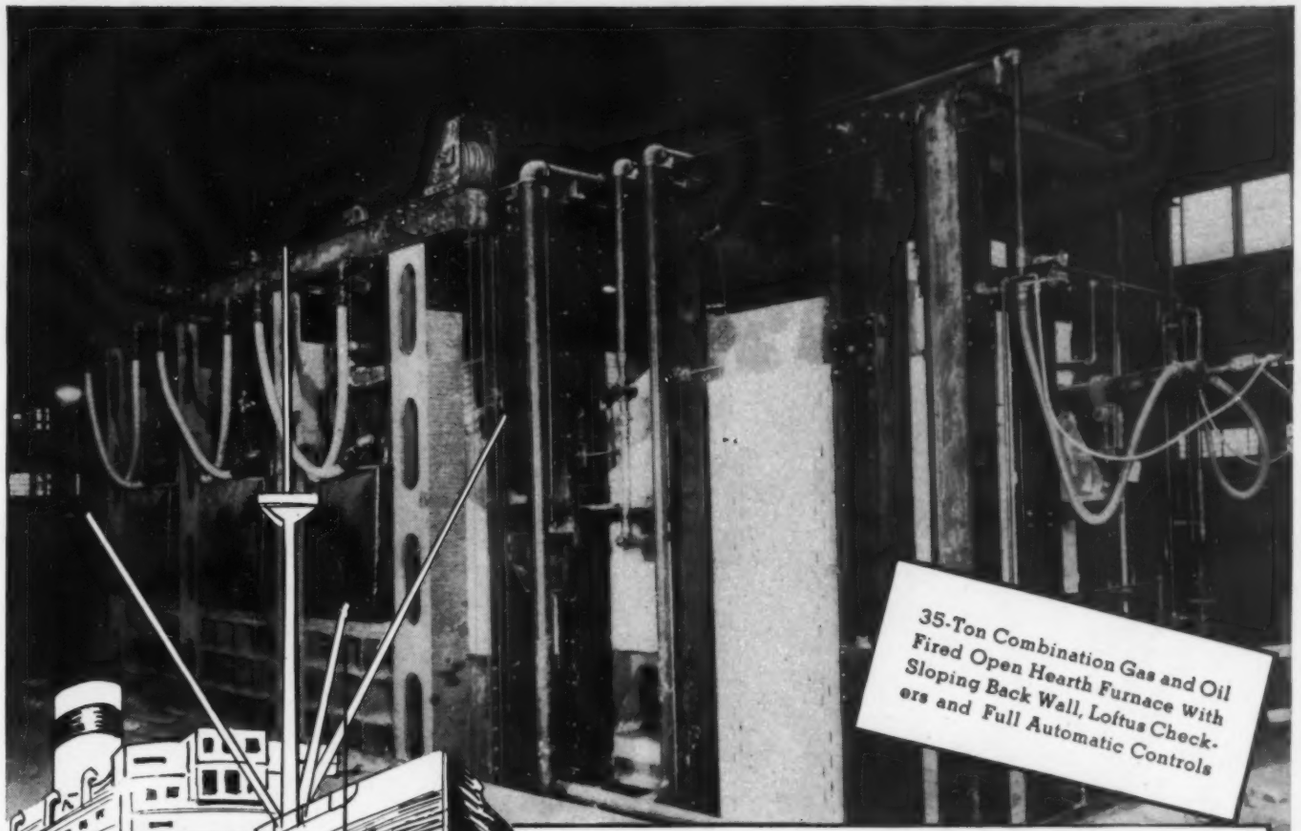
The Hays Visio-Ratio Gage is unique among indicating instruments because it performs the functions of three indicators—air-flow, fuel-flow and ratio.

Illustrated is a Visio-Ratio Gage which measures the flow of gas to a gas fired industrial furnace and the flow of air used for the combustion of the gas. Both these scales are calibrated in rate of flow in 1000 cu. ft. per hour.

The center scale is calibrated to show the percentage of excess of deficiency of air used to burn the gas with a range of 30% deficiency to 50% excess.

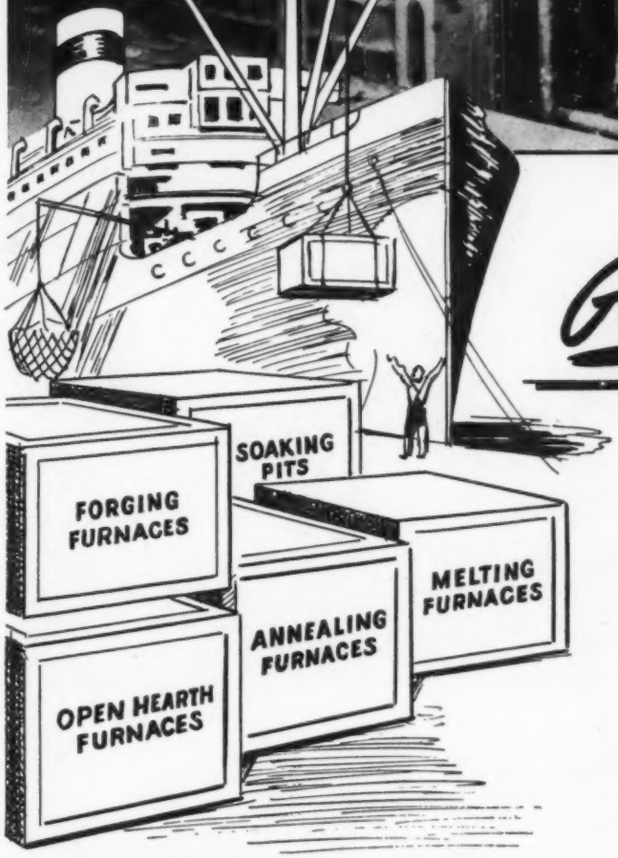
The spot at which the pointers cross over the center scale indicates directly the percentage of excess of deficiency of air used for combustion, eliminating the mathematical calculations which otherwise would be required with each change in flow of gas or air. The ratio used depends on the type of flame desired—oxidizing or reducting.

The HAYS CORPORATION
COMBUSTION INSTRUMENTS AND CONTROL
MICHIGAN CITY, INDIANA U.S.A.



35-Ton Combination Gas and Oil Fired Open Hearth Furnace with Sloping Back Wall, Loftus Checkers and Full Automatic Controls

# Geared for Export!




**Melting, Heating and Industrial Furnaces for Steel Mill, Foundry, Aluminum, Copper and Brass.**

In this country and throughout the civilized world modernization is the keynote in industrial reconversion and rehabilitation. With broad experience and highly trained staff the Loftus Engineering Corporation is prepared and equipped to serve in the modernization or complete construction of plants in any hemisphere.

*Consultation on export problems invited.*

610 SMITHFIELD ST. **LOFTUS ENGINEERING** *corporation* PITTSBURGH, PA.

**Designers and Builders** Engineers, Consultants, Contractors

BUILT BY MORGAN *Engineering*

ONE OF TWO MORGAN 200-TON, 63'0" SPAN UNIVERSAL TYPE INGOT STRIPPERS IN A MID-WESTERN ELECTRIC FURNACE STEEL PLANT

The Stripper as illustrated will perform three distinct stripping operations without change in the stripping unit.

(1) Strip small-end-up or standard ingots.
(2) Strip big-end-up hot top ingots.
(3) Break small-end-up ingots loose from stools.

With this type of Stripper it is possible to strip a mixed heat without lost time.

Additional Morgan equipment in this plant includes: Two 300-Ton, 65'0" Span Pouring Cranes. Three 150-Ton, 65'0" Span Pouring Cranes. Two 150-Ton, 80'3" Span Hot Metal Charging Cranes.

THE MORGAN ENGINEERING CO.
ALLIANCE, OHIO. 1423 Oliver Building, Pittsburgh

DESIGNERS • MANUFACTURERS • CONTRACTORS • BLOOMING MILLS • PLATE MILLS • STRUCTURAL MILLS • ELECTRIC TRAVELING CRANES • CHARGING MACHINES • INGOT STRIPPING MACHINES • SOAKING PIT CRANES • ELECTRIC WELDED FABRICATION • LADLE CRANES • STEAM HAMMERS • STEAM HYDRAULIC FORGING PRESSES • SPECIAL MACHINERY FOR STEEL MILLS

# Personnel News

**G. G. Beard,** former vice president in charge of sales for United Engineering and Foundry Company, Pittsburgh, Pennsylvania, has been appointed vice president and executive assistant to the president of that company. **K. C. Gardner, Jr.,** has been elected vice president in charge of operations for United. Mr. Gardner was formerly assistant to the general manager in charge of operations. **William Hagel,** formerly vice president in charge of machinery sales, has been made vice president in charge of sales.

**John B. Mitchell** was appointed assistant to the operating vice president of the Jones & Laughlin Steel Corporation effective January 1, 1946. Mr. Mitchell's entire business career has been in the steel industry. He started with J & L on September 1, 1915 in the Aliquippa Works Machine Shop, became assistant steam engineer and later superintendent of the 14 in. mill. For the past eight years, he has been superintendent of the rolling mills at the J & L Pittsburgh Works. He is a member of the Association of Iron and Steel Engineers.

**R. W. Campbell** was recently appointed superintendent of coke division of the Pittsburgh district of the Jones & Laughlin Steel Corporation. Mr. Campbell started with J & L as chief chemist at the coke plant. For the past 18 years he has been superintendent of the Pittsburgh coke plant.

Other changes at J & L's Pittsburgh and Aliquippa coke plants include the appointments of **F. L. McIntire** as superintendent; **E. J. Heastan** as assistant superintendent and **F. C. Lauer** as general plant foreman at the Pittsburgh plant; at the Aliquippa plant, **J. J. Cavett** was appointed superintendent; **W. C. Hall** assistant superintendent, and **E. M. Gillespie** as general plant foreman.

**Lawrence E. Riddle,** general superintendent of Isabella Furnaces of Carnegie-Illinois Steel Corporation at Etna, Pennsylvania, has retired after 53 years continuous service with this U. S. Steel subsidiary.

Upon his retirement, the management of Isabella Furnaces was combined with the Clairton Steel Works under **H. W. Seyler** as general superintendent of combined operations. Isabella Furnaces will now be identified as Isabella Furnaces of Clairton Steel Works.

Mr. Riddle began his career as an apprentice chemist at Isabella in 1892. He was made general superintendent in 1914, and in 1926 was given the added responsibility of superintending the blast furnace and sintering plants of the company's Duquesne Works, holding both positions until his retirement.

An authority on the production of all types of special iron as well as ferro-manganese and ferro-silicon products, Mr. Riddle has been responsible for many improvements in blast furnace construction, operation and control. He has seen the daily production of blast furnaces rise from a top of 200 tons to over 1400 tons a day in the largest new furnaces, with equivalent improvements in safety and ease of operation.

**Harry R. Gilchrist** who for about 23 years has been with Carnegie-Illinois Steel Corporation in the Youngstown District in engineering and maintenance, where he specialized in lubrication, has joined K. W. Atwater Engineering in further development, servicing and sales of "Lignalloy" roll neck bearings and associated products.

**Richard Stevens** has been appointed blast furnace superintendent at the Warren District of Republic Steel Corporation.

Mr. Stevens comes to Warren from the Republic plant in Youngstown where he has been employed since 1936 as superintendent of the coke works and later as assistant superintendent of the blast furnaces. A graduate of Cornell University in mechanical engineering, Mr. Stevens had previously been employed by the Public Service Company of New Jersey, Bethlehem Steel Corporation, Carnegie Steel Corporation and the Koppers Company.

K. C. GARDNER, JR.

JOHN B. MITCHELL

R. W. CAMPBELL

Remember IMO forget TROUBLE

The IMO PUMP has only three moving parts and no valves, timing gears, cams, or delicate adjustments to get out of order. It can be depended upon for hydraulic service, governor service, lubrication service and other applications in which continuity of operation is vital.

*For further information write for catalog I-126-I*

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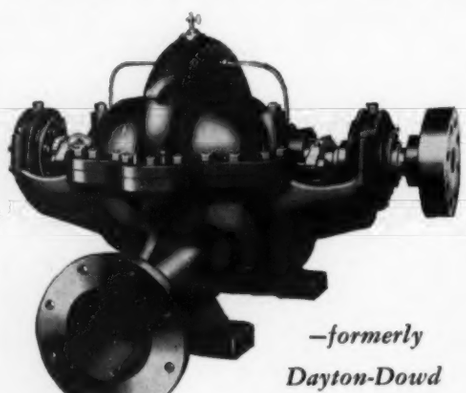
PUMP DIVISION OF THE
DE LAVAL STEAM TURBINE CO.
TRENTON 2, NEW JERSEY

**PEERLESS**
**HORIZONTAL PUMPS**



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*Dayton-Dowd*

*Continuous Duty*

Split-Case and Solid Volute Types

**PEERLESS PUMP DIVISION—FOOD MACHINERY CORP.**
Factories: Los Angeles, Cal. • Quincy, Ill. • Canton, Ohio

VERTICAL & HORIZONTAL

PEERLESS PUMPS

PEERLESS BUILDS WITH STEEL

A. L. RALSTON

**A. L. Ralston** has been appointed manager of roll sales for the Lewis Foundry and Machine division of Blaw-Knox Company. Mr. Ralston has been with the Lewis Foundry and Machine division since 1927, first as salesman, then as assistant manager of roll sales. Previous to that time he had been associated with various steel companies in the Pittsburgh district.

**Claude S. Lawson,** has recently been promoted from the position of general superintendent of blast furnaces, coke works and the Mary Lee Railroad for the Sloss Sheffield Steel & Iron Company, to the position of vice president of the Sloss Sheffield Steel & Iron Company, succeeding **B. F. Davis** who is retiring. **Fred Osborne,** formerly with Woodward Iron Company as assistant general superintendent, has returned to the Sloss Sheffield Steel & Iron Company to assume the position vacated by Mr. Lawson.

**Wm. A. Marsteller** has been appointed general advertising manager of Rockwell Manufacturing Company, Pittsburgh, it was announced by **A. J. Kerr,** vice president of sales of the Rockwell organization.

Mr. Marsteller has been vice president in charge of sales, advertising and industrial relations of Edward Valves, Inc., East Chicago, Indiana, a subsidiary of the Rockwell Manufacturing Company.

**Herbert Johnson** was made assistant to the vice president in charge of sales, of the Jones & Laughlin Steel Corporation, effective January 1.

Mr. Johnson, a graduate of Luther College, Decorah, Iowa and the Harvard Law School, has been employed in various capacities by J & L since 1940. He was a member of the company's legal department prior to his present appointment.

**C. Q. Wright** has returned to the employ of Whiting Corporation, Harvey, Illinois in the capacity of vice president dealing with special staff work. Capt. Wright served as a submarine commander in World War II. In 1911 he graduated from the U. S. Naval Academy at Annapolis. He later resigned his commission to enter the business world. After holding executive positions with several national organizations, he came to Whiting in 1939 and was vice president in charge of sales until he left to rejoin the Navy shortly after Pearl Harbor.

**W. Morrison,** ssociaated with the Brooks Oil Company since 1935, has been appointed sales manager for that company. **Thomas M. Stonerod,** with Brooks Oil for ten years, has been appointed Pittsburgh district manager, and **Joseph A. Rigby,** who joined the company in 1944, has been appointed chief engineer.

**I. C. Smith** has been appointed chief engineer of the Crocker-Wheeler Division of Joshua Hendy Iron Works, Ampere, New Jersey.

Mr. Smith has had wide experience in both the electrical and mechanical aspects of electric motor design. Prior to joining Crocker-Wheeler in May of 1942 as a designer of direct-current motor and generator equipment, he spent more than twelve years with the Elliott Company of Ridgway, Pennsylvania, where he was in charge of d-c design. Prior to this he was a design engineer with Westinghouse.

I. C. SMITH

**Fred E. Harrell,** general works manager of The Reliance Electric & Engineering Company, Cleveland, was elected a member of the board of directors at the annual meeting of stockholders, January 17.

Born in Logansport, Indiana, Mr. Harrell has been with Reliance since 1924, when he was graduated from Purdue University. He was made assistant chief engineer in 1934, served as executive director of the company's Marine Division plant during the early part of the war, became chief engineer of the company in 1943 and general works manager in 1945.

**L. T. Shorley** has been elected president and treasurer of the Freyn Engineering Company, Chicago, Illinois. His election was effective February 1, 1946. He succeeds **Wyman Eaton** who retires as president but continues as a director of the company.

**Robert M. Zeller,** formerly with the Carpenter Steel Company of Reading, Pennsylvania, is now associated with the Aetna-Standard Engineering Company of Youngstown, Ohio. Mr. Zeller is a roll designer and his capacity in the Roll Sales Division at Aetna-Standard will be that of roll engineer.

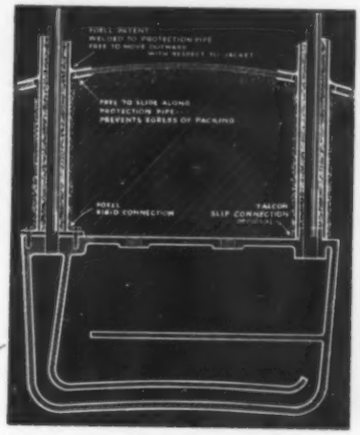
**Melvin C. Shaw** has been named manager of the


FALCON
NECKLESS COOLING PLATES

• VERTICALLY CAST WITHOUT ANCHORS OR CHAPLETS

• The advantages of Falcon's "Anchorless" casting method are: 1—sound castings; 2—uniform wall thickness; 3—density of copper at nose, due to vertical casting; 4—freedom from oxide and sand inclusions; 5—absence of blow holes; 6—longer, trouble-free performance.

This Falcon Neckless Cooling Plate with patented Foell jacket attachments is made by the "Anchorless" method.



U S PATENTS 2,345,188 2,252,605 2,252,606 2,319,571

Made with feed and discharge adjacent or at opposite ends of plate

TELEPHONE COLLECT—34355

FALCON BRONZE CO.
YOUNGSTOWN 3, OHIO
Established 1890 . . . Incorporated 1895

YOUR NEW MAN FOR BETTER SERVICE

SPECIALIZING IN REBUILDING AND REMODELING OF ALL TYPES OF INDUSTRIAL FURNACES

A New Name to You, but One You'll be Pleased to Know . . . to do those important maintenance jobs. Write or phone us your problem of construction. All inquiries given our prompt attention.

- ENGINEERS
- CONTRACTORS
- AGENTS

LAUGHLIN
CONSTRUCTION SERVICES, Inc.
535 MULBERRY STREET - EAST LIVERPOOL, OHIO

# CROUSE-HINDS

# Plugs and Receptacles

The illustrations show a representative selection from the hundreds of different electrical plugs and receptacles that are listed in Crouse-Hinds CONDULET Catalog No. 2500. A full range of sizes — 10 amperes to 400 amperes, up to 600 volts A. C.

**No. 5**

of a series of advertisements which demonstrate that CROUSE-HINDS "complete line" means much more than just a range of sizes — there is a wide variety of highly specialized types in each classification.

Type C Condulet with Double T Slot Receptacle

Type C Condulet with Receptacle

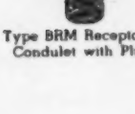
Type DXE Condulet with Twist Lock Receptacle

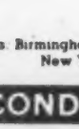
Type FS Condulet with Pilot Light, Switch and Receptacle

Type FS *Two-gang Tandem* Condulet with Switch and Receptacle

Type FSC Condulet with Type BRD Receptacle and Plug

Type BHMF Receptacle Condulet for Flush Mounting with Plug


Type BRME Receptacle Condulet


Type BRM Receptacle Condulet with Plug

Type FS Weatherproof Receptacle Conduiet with Locking Cover

Type FSC Receptacle Conduiet with Three Receptacles and a Watertight Plug

Type FS Condulet with Type FAR Arktite Receptacle

Type PRB Receptacle Condulet with Five Receptacles

Type GSP Portable Receptacles with Plug *Three-Gang*

Type BR Extension Cable Connector Double Receptacle

Type BRC Extension Cable Connector Receptacle and Plug

Type ARE *Arktite* Receptacle

Type AEQ *Arktite* Receptacle *for Flush Mounting*

Type ARRC Condulet with *Arktite* Receptacle

Type BRW Watertight Double Receptacle Condulet with Plug *for Railroad Yards*

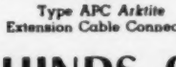
Type ARD Condulet with *Arktite* Receptacle

Type WMKS Interlocking Safety Switch and Receptacle

Type AJ Condulet with *Arktite* Receptacle

Type QEEH Delayed Action *Arktite* Receptacle

Type GST Condulet with Type BRG Receptacle and Plug


Type APC *Arktite* Extension Cable Connector

Type AREX *Arktite* Receptacle

Type APF Fusible *Arktite* Plug, Exploded View

Adjustable Type EHS Explosion-Proof Delayed Action Receptacle Condulet

Type AEQ *Arktite* Receptacle for Flush Mounting, *Two-gang*

Type AREA *Arktite* Receptacle


Type AREA *Arktite* Receptacle

Type FSQ Explosion-Proof Interlocking Receptacle and Switch

Type CES Explosion-Proof Delayed Action *Arktite* Receptacle

Type CPS Explosion-Proof Delayed Action *Arktite* Receptacle with Plug

Type CPS Explosion-Proof Delayed Action *Arktite* Receptacle, *Two-gang*

Type FSQC Explosion-Proof Interlocking Receptacle and Switch

A Nationwide Distribution Through Electrical Wholesalers

## CROUSE-HINDS COMPANY

**Syracuse 1, N. Y., U.S.A.**

*Offices:* Birmingham — Boston — Buffalo — Chicago — Cincinnati — Cleveland — Dallas — Denver — Detroit — Houston — Kansas City — Los Angeles — Milwaukee — Minneapolis New York — Philadelphia — Pittsburgh — San Francisco — Seattle — St. Louis — Washington. *Resident Product Engineers:* Albany — Atlanta — Charlotte

CROUSE-HINDS COMPANY OF CANADA, LTD., *Main Office and Plant:* TORONTO, ONT.

**CONDULETS · TRAFFIC SIGNALS · AIRPORT LIGHTING · FLOODLIGHTS**

ARTHUR D. BEERS

DAVID L. SIMPSON

LESTER R. PEARSON

blower and compressor department at the Allis-Chalmers Manufacturing Company, Milwaukee, Wisconsin. He succeeds **John Avery,** who has resigned to become president of a blower corporation in Indiana.

Mr. Shaw, with Allis-Chalmers since 1914 when he was graduated from the University of Washington, has been chief engineer since 1935 of the department he will now head.

**Arthur D. Beers,** formerly assistant superintendent of the central mills at Gary works of Carnegie-Illinois Steel Corporation, has been promoted to the superintendency, succeeding **J. C. Wilkins,** retired. Mr. Beers has been associated with the plant since April 1911 when he started as a chemist.

**David L. Simpson,** formerly assistant chief metallurgist of the plant, has been made superintendent of the 12-1 and 12-2 merchant mills, succeeding **William Lange,** resigned. He started as a metallurgical observer in 1935.

**Lester R. Pearson,** formerly assistant to superintendent of the Gary works roll shop has been made superintendent, succeeding **Robert S. McCleery,** retired. He has been associated with the plant since 1917.

**Victor E. Schlossberg** has been appointed superintendent of the electric and power departments of the Indiana Harbor works of the Inland Steel Company. Mr. Schlossberg, after graduation from Rose Polytechnic Institute, started work with the Inland Steel Company in 1926. Prior to this appointment, he has been assistant superintendent of the electric and power departments. Mr. Schlossberg succeeds **W. A. Perry** who is now assistant to the general superintendent.

**Lt. Robert S. Aitchison, USNR,** has rejoined the Lindberg Engineering Company to take charge of the advertising department. Prior to his entry into the Navy, he handled sales promotion for Lindberg and also directed production of the "Heat Treating Hints" movies produced by that company.

**H. C. Bostwick** has been made district representative of the Drever Company, Philadelphia, Pennsylvania, in the area including western Pennsylvania, western New York, and Ohio. He will make his headquarters at 3277 Kenmore Road, Shaker Heights, Ohio. Mr. Bostwick has 18 years experience in the industria furnace field and previous to that had spent 5 years in the steel industry.

**G. C. Derry,** vice president and general manager of the B. F. Sturtevant Company, Boston, Massachusetts has been named president of the National Association of Fan Manufacturers at the Twenty-Ninth annual meeting of the Association. **R. H. Nelson,** president of the Herman Nelson Corporation, Moline, Illinois has been named vice president of the Fan Association and **L. O. Monroe** has been named secretary-treasurer.

**L. M. Cassidy** and **T. K. Mial** have been elected vice presidents of the Johns-Manville Corporation. Mr. Cassidy was formerly a vice president of the Johns-Manville Sales Corporation, a subsidiary, in charge of the building materials and general department. Mr. Mial also formerly a vice president in the Sales Corporation was in charge of the power products and industrial department. The announcement follows the retirement of **L. R. Hoff,** vice president of Johns-Manville Corporation in charge of sales.

In his new capacity, Mr. Cassidy will direct all sales activities of the company. Mr. Mial will undertake a new long-range development program for the company, reporting directly to the president, **Lewis H. Brown.**

**J. A. O'Brien,** vice president of Johns-Manville Sales Corporation, has been appointed manager of the power products and industrial department. He will also serve as a member of the officers board. Mr. O'Brien began his career with Johns-Manville in 1915 after being previously associated with the Ireland Rubber Company. Prior to his new appointment, he was general sales manager of the department he now heads.

**H. R. Berlin** has been elected vice president of Johns-Manville Sales Corporation and is appointed manager of the building materials and general department of the company. He will also serve as a member of the officers board. Mr. Berlin joined Johns-Manville in 1926 as an acoustical engineer.

**C. G. Dandrow,** of 109 Ogden Avenue, White Plains,

*If You Want to Slash*
**METAL CUTTING & TRIMMING COSTS FROM DOLLARS TO PENNIES**

**KLING** *Friction Saws Cut All these Bars and Shapes in a few Seconds*

*Read this*

24" 100# I-BEAM 28 SECONDS

15" 55# CHANNEL 15 SECONDS

8"x8"x343# H-BEAM 10 SECONDS

9 SECONDS 100# A.R.A. RAIL

5 SECONDS 6½"x6½"x19.8# TEE

11 SECONDS 8"x8"x¾" ANGLE

10 SECONDS 3" SQUARE

15 SECONDS 4" ROUND

11 SECONDS 6" O.D. TUBE ½" WALL

NO CHANGE OF BLADE OR SET-UP NECESSARY

**INCREASES PRODUCTION...**

***CUTS ALL CLASSES OF STEEL - QUICKLY AND ECONOMICALLY***

**The versatile ability of the Kling Friction Saw to cut varied structural shapes in any sequence, without change of blade or set-up, permits one machine to handle various types of work which, otherwise, would require several slow speed saws to handle.**

**The installation of a Kling Friction Saw will quickly convince you of its superiority and advantages over the old type of saw. Furthermore, you will cut your cutting costs — savings will be effected in time and labor because of speed and efficiency of the Kling Saw.**

**GET COMPLETE INFORMATION**

**CONSULT KLING ENGINEERS REGARDING YOUR CUTTING PROBLEMS. WRITE FOR BULLETIN No. 9200 GIVING VALUABLE INFORMATION. SENT WITHOUT COST OR OBLIGATION.**

**Kling Bros. Engineering Works**

**1300—IS North Kostner Ave., Chicago 51, Ill.**

**EXPORT DEPT. — 1111 So. Ferry Bldg. New York 4, New York**


New York, has been elected a vice president of Johns-Manville Sales Corporation and is appointed general sales manager of the power products and industrial department. Mr. Dandrow joined the Johns-Manville organization in 1922 directly following his graduation from the Massachusetts Institute of Technology. After five years in the Boston branch office of Johns-Manville he joined the general engineering staff at the New York headquarters, and was New York district sales manager.

**J. D. Wright,** manager of the General Electric Company's industrial engineering divisions announced that three new divisions, power electronics, materials handling and testing equipment, and rubber and printing have been formed. In addition the machinery division has been reorganized. **L. W. Morton** is head of the new power electronics division, which is concerned with the application of electronics to the problem of power conversion in industry. **M. A. deFerranti** has been named engineer of the materials handling and testing quipment division. It deals with elevators, cranes and hoists. **G. W. Knapp** will head the rubber and printing divisions. **H. W. Poole** will head the reorganized machinery division, which will apply new and improved drives to the machine tools and automatic machinery industries.

**C. I. MacGuffie,** manager of the welding division announced the following organization for the division: **W. L. Immer** is now assistant manager; **W. W. Churchill** is in charge of the equipment group; **H. O. Westendarp, Jr.,** heads the electrode group; **B. C. Tracey** is in charge of the accessory group; and **R. F. Wyer** is in charge of the application engineering group.

**C. L. Ipsen,** manager of the industrial heating division has announced the following organization for this unit. **R. D. Ketner** is manager of sales of the industrial heaters and devices section; **O. S. Haskell** is now manager of sales of the electric furnace and oven section; **K. E. Kjolseth** is manager of sales of the induction and dielectric heating section and **R. M. Cherry** is assistant manager of the division.

**C. G. Pommer** has been appointed manager of the ordnance division, which division's name previously had been ordnance control division. Mr. Pommer succeeds **C. E. Clark** who will serve as consultant to the division.

**Charles Shapiro** is president of the Laughlin Construction Services, a new company specializing in rebuilding and remodeling all types of industrial furnaces, and in general contracting, whose formal incorporation under the state laws of Ohio has just been made. Mr. Shapiro was formerly associated with Salem Engineering Company, Salem, Ohio. **Earl R. Cole,** vice president of the new organization, was formerly sales representative and field construction superintendent of Loftus Engineering Corporation, Pittsburgh, Pennsylvania. **Lawrence Shapiro** has been named secretary and treasurer of the company.

**K. W. Green,** manager of Exide's Railway Sales Division, has been appointed manager of the newly consolidated railway and engineering sales division, according to an announcement by The Electric Storage Battery Company, Philadelphia.

## "... I have not found any dies that compare with Mackhempite"

We honestly don't believe that any metal can give you the service you'll get with our Red Top Hammer Dies.

But, you don't have to take our word for it. Here's a letter from an internationally famous tool steel plant — it's typical — we quote:

*"In my 49 years experience with the various kinds of dies I have not found any that compare with Mackhempite. They cannot be excelled for hammering unusually dense, tough steel. Die problems here were a regular headache until we used your Chrome-Moly composition."*

Our Red Top Dies are equally good for Tilt hammers or heavy cogging and in their 15 years of universal use for flat hammering of tool steel they have set unequaled records for holding a level face. Write for prices or, if you prefer, specify them to your hammer builder.

**M-H HAMMER PARTS**

- Dies
- Sow Blocks
- Rams
- Side Frames
- Bases

# Mackintosh-Hemphill Company

**PITTSBURGH AND MIDLAND, PA.**

*MAKERS OF THE ROLLS WITH THE RED WABBLERS*

The use of De Laval double reduction worm gears for operating the screw-downs on this Farrel-Birmingham sheet rubber calender illustrates the extreme compactness of this type of drive for transmitting high torques at high reduction ratios. Each screw-down is adjusted by means of a separate motor and reducer unit, making it possible either to adjust each end of each roll independently or to synchronize the adjustment of both ends in parallel.

1153

TURBINES • HELICAL GEARS and WORM GEAR SPEED REDUCERS CENTRIFUGAL PUMPS • CENTRIFUGAL BLOWERS and COMPRESSORS • IMO OIL PUMPS

WORM GEAR DIVISION
DE LAVAL
STEAM TURBINE COMPANY · TRENTON 2, NEW JERSEY

SALES OFFICES ATLANTA • BOSTON • CHARLOTTE • CHICAGO • CLEVELAND • DENVER DETROIT • HELENA • HONOLULU • HOUSTON KANSAS CITY • LOS ANGELES • MANILA MONTREAL • NEW HAVEN • NEW ORLEANS NEW YORK • PHILADELPHIA • PITTSBURGH ROCHESTER • ST. PAUL • SALT LAKE CITY • SAN FRANCISCO • SEATTLE • TORONTO • TULSA VANCOUVER • WASHINGTON, D.C. • WINNIPEG And Cities in Central and South America

Mr. Green, during the past four years, has been supervising the engineering sales division in addition to his duties as head of the railway division.

**J. B. Kintner** has resigned as vice president of the Union Steel Castings Division of Blaw-Knox Company to establish his own company in Pittsburgh, Pennsylvania. The new organization, which is known as the J. B. Kintner Company, is operating as a manufacturers' agency with offices in the Union Trust Building. At present the agency's clients include Pittsburgh Steel Foundry Corporation of Glassport, Pennsylvania, and Fort Pitt Steel Casting Company of McKeesport, Pennsylvania.

Mr. Kintner was graduated from Purdue University in 1925. He was employed by The American Rolling Mill Company as a sales representative in Middletown, Ohio, Detroit, Michigan, and in Pittsburgh during 1925-36 before becoming affiliated with the Blaw-Knox subsidiary in 1936. He served there as vice president of Union Steel Castings, a position he held until last month when he resigned to establish his own business.

**H. D. Moreland** has been appointed manager of the Westinghouse X-Ray Division, Baltimore, Maryland. Mr. Moreland succeeds **A. P. Craig** who will assume important duties with the Westinghouse Canadian Company.

A native of Norris City, Illinois, Mr. Moreland received his BS in Electrical Engineering at Oregon State College in 1930 and his MS from the same institution two years later. Mr. Moreland has been associated with the X-ray industry continuously since 1933, joining Westinghouse that year as an X-ray serviceman at Portland, Oregon.

**A. L. Atherton** was appointed advisory engineer and **Fred C. Heyl** manager of the quality control department at the East Springfield, Massachusetts plant of the Westinghouse Electric Corporation. Mr. Atherton, formerly manager of the quality control department, will be responsible for expediting and analyzing problems of all East Springfield products, to insure coordination with design, service and manufacturing engineers and district offices. Mr. Heyl was quality control department manager at the Center Line, Michigan, Naval Ordnance plant operated by Westinghouse before his transfer to East Springfield.

**D. J. Stone** has been appointed engineering manager of the stoker department of the Westinghouse Electric Corporation's steam division at Philadelphia, Pennsylvania. He succeeds **R. A. Foresman,** who had been on extended service for several months prior to his retirement.

**O. P. Adams** has been appointed director of development for the National Tube Company. Mr. Adams has been assistant general superintendent of the company's National Works, McKeesport, Pennsylvania, since September, 1942.

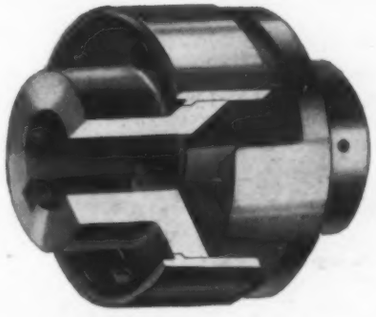
Also announced was the appointment of **T. H. Kennedy** as assistant general superintendent at National Works and the retirement of **J. Jay Dunn** as assistant to vice president of operations.

Mr. Adams is a native of Locust Ridge, Louisiana,


*Protect*

**YOUR MACHINERY FROM**

- **MISALIGNMENT**
- **VIBRATION AND SHOCK**
- **BACKLASH**
- **INTERNAL FRICTION**



Patent and Patents Pending

L-R Type "HQ" (Heavy Duty) 3.91 to 744 H. P.

**L-R**

**FLEXIBLE COUPLINGS**

L-R Flexible Couplings safeguard drive and driven units. Free-floating load cushions hung between strong metal jaws are free to deform to every requirement. *The quiet coupling!* Cushions always in sight. SEND FOR COMPLETE CATALOG WITH SELECTOR CHARTS.

**Lovejoy Flexible Coupling Co.**

5016 W. LAKE ST. CHICAGO 44, ILL.

Pittsburgh Office: EDW. J. BOYLE CO., 508 Grant Street

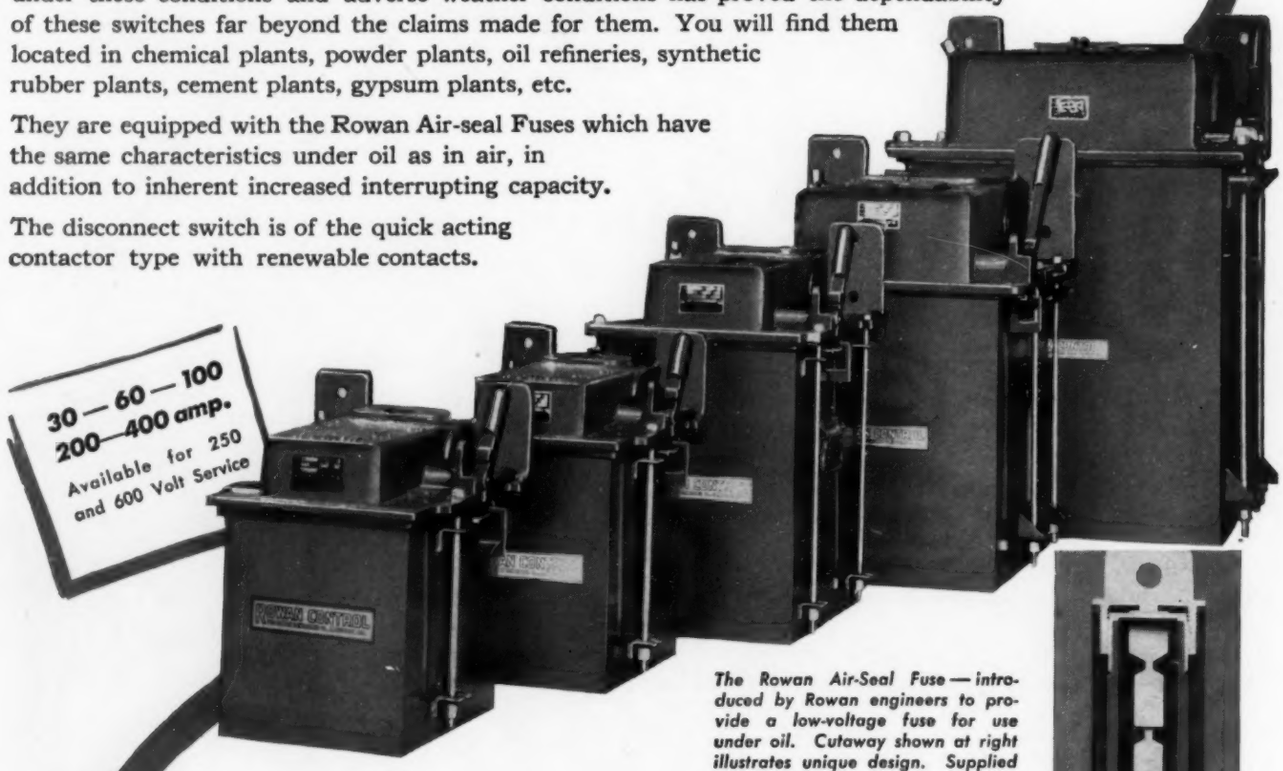
# FOR MAXIMUM SAFETY AND CONTINUITY OF SERVICE

# Rowan COMPLETELY OIL IMMERSED, FUSED, SAFETY LINE DISCONNECT SWITCHES

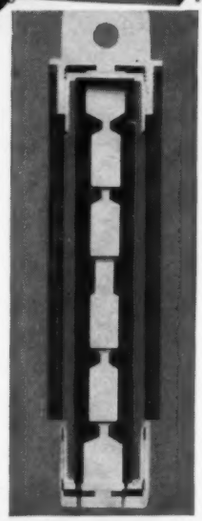
Designed and time-tested for locations where the atmosphere is contaminated with corrosive elements, semi-hazardous and hazardous vapors and dust. Continuity of service under these conditions and adverse weather conditions has proved the dependability of these switches far beyond the claims made for them. You will find them located in chemical plants, powder plants, oil refineries, synthetic rubber plants, cement plants, gypsum plants, etc.

They are equipped with the Rowan Air-seal Fuses which have the same characteristics under oil as in air, in addition to inherent increased interrupting capacity.

The disconnect switch is of the quick acting contactor type with renewable contacts.




*The Rowan Air-Seal Fuse — introduced by Rowan engineers to provide a low-voltage fuse for use under oil. Cutaway shown at right illustrates unique design. Supplied in 30—60—100—200—400 amp., 250 and 600 Volt.*



***Other features of the Rowan Oil Immersed Disconnect Switch are:***

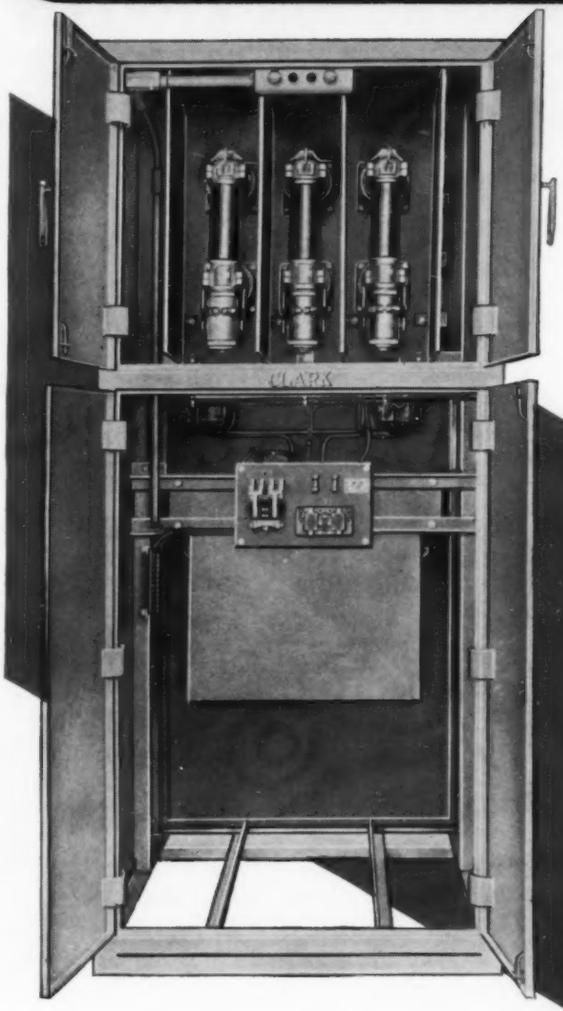
**1**—ROWAN AIR-SEAL fuses. **2**—Completely oil immersed. **3**—Disconnect switch of the quick acting contactor type with renewable contacts. **4**—Safety enclosing case mechanically interlocked to prevent lowering of tank when switch is in operating position or closing of switch when tank is lowered. **5**—Enclosing case is weather-resisting and dust-tight. **6**—PROVISION for locking disconnect switch in "off" position. **7**—Tank handles for ease of handling.

*The Rowan Controller Company has specialized in Oil Immersed Controls for nearly half a century. Results and performance achieved by users justify the Rowan claim of superiority in this field. Write for complete information on Rowan Oil Immersed Controls.*

**ROWAN CONTROL**

THE ROWAN CONTROLLER CO., BALTIMORE, MD.

# HIGH VOLTAGE MOTOR STARTERS
## *High Interrupting Capacity*
## UNIT STEEL CUBICLE CONSTRUCTION



"3C" Bulletin 6018 Type HI Motor Starter Front View —Open.

The "3C" Bulletin 6018 Type HI Motor Starter illustrated provides 150,000 K. V. A. Interrupting Capacity at 2300 Volts, 60 cycle.

These Starters are housed in steel cubicle units capable of installation singly, or in groups complete with integral bus work for multi-motor groups.

"3C" Bulletin 6018 Type HI Motor Starter Rear View, Tank Down.

Equipment is available for furnishing these Starters for use with Squirrel Cage, Synchronous, and Wound-Rotor Motors.

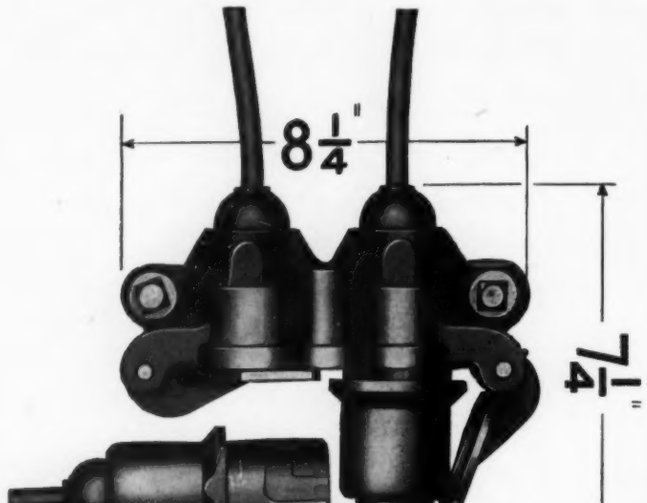
Heavy-Duty Oil-immersed Contactors provide reliable service, and Magnetic Overload Relays give full, dependable Overload protection.

***For complete information on "3C" High Voltage Motor Starters, contact our nearest District Office, or the Home Office in Cleveland.***

**THE CLARK CONTROLLER CO.**

1146 EAST 152nd ST., CLEVELAND 10, OHIO • EVERYTHING UNDER CONTROL

# OHIO ARMORED
## WEATHER PROOF
## CONNECTORS




Save time to make or break connections.

They are operated by hand, (see the Bayonet Joint in Cut).

No Tools or Tape required.

No danger, live parts covered by insulated Iron Shell.

Two Pole Connectors have Automatic Spring Cover closing live end when not connected.

They also have support Ears for mounting (see cut).

Single Pole Connectors are furnished without Spring Closing Covers or Support Ears.

Cable Ends are No. 4 B & S Extra Flexible Insulated Wire.

Capacity 150 amperes continuous.

| | Weight | Net Price |
|---|---|---|
| Single Pole Connectors | 5 Lbs. | $12.00 Each |
| Double Pole Connectors | 13½ Lbs. | $25.00 Each |
| Lower or Plug End Separately | | $ 7.50 Each |

Priority required — F. O. B. CLEVELAND

OHIO reliable MAGNETS

**The OHIO Electric Mfg. Company**
**5907 Maurice Avenue**
**Cleveland 4, · · Ohio**



# Positive Pressure Lubrication Protects

Pressure application systems insure dependable lubrication that keeps machines in steady operation — provided you use the most efficient lubricant.

NON-FLUID OIL positively qualifies. It contains nothing to make residue, so cannot clog fittings and allow bearings to run dry.

Because it lasts longer, it reduces lubricant and application cost by requiring less frequent application. Positively neutral, NON-FLUID OIL is recommended by most makers of ball and roller bearings.

Used successfully in leading iron and steel mills. Send for instructive bulletins and free testing samples.

•

**New York & New Jersey Lubricant Co.**
Main Office: 292 Madison Ave., New York 17, N. Y.
WAREHOUSES:

Chicago, Ill. — Atlanta, Ga.
St. Louis, Mo. — Detroit, Mich.
Providence, R. I. — Charlotte, N. C. — Greenville, S. C.

50 YEARS OF SERVICE TO INDUSTRY
NON-FLUID OIL
1896 - 1946

*Modern Steel Mill Lubricant*

*Better Lubrication at Less Cost per Month*

THOMAS C. FORD

DR. GEORGE V. SLOTTMAN

RUSSELL J. GREENLY

and was graduated from Millsaps College and Tulane University. Later, he studied naval engineering at the U. S. Naval Academy. He joined National Tube in 1929 as superintendent of mechanical power at National Works.

Mr. Kennedy was born at Big Stone Gap, Virginia and attended Virginia Polytechnic Institute and earned a metallurgical degree at the Missouri School of Mines and Metallurgy. He began his career with Pittsburgh Crucible Steel Company in 1926 as an apprentice and joined National Tube in 1940 as assistant superintendent of blast furnaces at National Works. Prior to this, he was blast furnace superintendent at Interlake Iron Corporation, Toledo, Ohio.

**Thomas C. Ford** has been appointed district manager of the Pittsburgh office of Electro Metallurgical Sales Corporation. Mr. Ford was graduated from Yale University in 1931 with a degree in mechanical engineering. He worked from 1932 to 1936 with the Carnegie Steel Corporation. In 1936 he became a service metallurgist of Electro Metallurgical Company, a unit of Union Carbide and Carbon Corporation. He has been associated with the company offices in Pittsburgh, Birmingham and Chicago.

**Dr. George V. Slottman** has been appointed the head of a new technical sales division of the Air Reduction Company, New York. The new division replaces Airco's former applied engineering department. It was also announced that **S. D. Baumer** and **E. V. David,** who have been assistant managers of the applied engineering department, are now assistant managers to Dr. Slottman in the new sales division.

**Russell J. Greenly** has been placed in charge of personnel administration of Jones & Laughlin Steel Corporation. Mr. Greenly, formerly chief of personnel and training for Carnegie-Illinois Steel Corporation, recently completed one and a half years' service with the War Production Board, Steel Division, as Deputy in Charge of Industrial Relations activities. Prior to his affiliation with Carnegie-Illinois, he was Professor of Trades and Industrial Education at Purdue University from 1936 to 1941.

**Dr. W. A. LaLande, Jr.** has been appointed director of Whitemarsh research laboratories of the Pennsylvania Salt Manufacturing Company.

Dr. LaLande, formerly director of research of the Attapulgus Clay Company, and previously a member of the chemistry faculty of the University of Pennsylvania, came to Pennsalt in August 1944 as director of the research division. In his new position, he will have charge of all activities at the new Whitemarsh research laboratories except those of the patent division. These activities include laboratory research, pilot plant operations, product evaluation studies, and technical sales service work.

**James McWhirter** has been appointed superintendent of the Pennsylvania Salt Manufacturing Company's Natrona plant. Mr. McWhirter, who succeeds **Charles G. Boone,** retired, came to Pennsalt in 1945 after eight years experience in the heavy chemical industry. Before joining Pennsalt in Philadelphia he had been superintendent of plants in Detroit and Cleveland for the General Chemical Company.

## *Obituaries*

**Louis N. McDonald,** former general superintendent of the Youngstown Ohio Works of the Carnegie-Illinois Steel Corporation died on January 14th at his home in Daytona Beach, Florida after a short illness. Mr. McDonald retired in 1940 after 51 years service with the steel company and had gone to Florida a week prior to his death. Mr. McDonald was first employed at the Duquesne Works of the Carnegie Steel Company and went to Youngstown in 1902, where he served as superintendent of the Bessemer department and became general superintendent in 1925. He was credited with several inventions for the improvements of steel making processes, etc.

**Alfred G. Cutts,** chief engineer to Messrs. John Summers & Sons, Ltd., Shotton, Chester, England, died recently. Mr. Cutts was formerly chief electrical engineer of the company. Mr. Cutts was one of the oldest members of the A. I. S. E. in England.

# ABC statement of Material Handling Facts

**for busy manufacturers with an eye on the shrinking spread between labor costs and price ceilings . . .**

Most management men in industry are aware of the many advantages of mechanizing handling of material in plant and warehouse. The basic facts outlined below deserve the consideration of any executive concerned with this problem.

## A THE CASE FOR POWER INDUSTRIAL TRUCKS

1. **They conserve manpower.** One operator with a power truck can do the work of 6 - 10 men with hand trucks.
2. **They conserve time.** Besides speeding transportation of material, they load and unload cars faster, and save time on many other handling operations.
3. **They conserve space.** Fork trucks, Hy-Lift trucks, and crane trucks can tier material to make floor space more valuable.
4. **They promote safety** by eliminating the strained backs, hernias, crushed fingers or toes and other accidents resulting from manual lifting.
5. **They speed production.** By keeping materials moving, bringing work right to machines, keeping aisles clear, fast changing of dies, they reduce idle machine time and step up production schedules.
6. **They are flexible.** Not limited by crane-ways or tracks, they can operate anywhere—indoors and out—wherever needed.

## B THE CASE FOR ELECTRIC POWER INDUSTRIAL TRUCKS

1. **Continuous Operation.** Always dependable—always on the job, electric trucks are built for long, hard service. Changing batteries takes less time than changing oil or re-fueling non-electric trucks.
2. **Lowest Maintenance Cost.** Case histories show that with proper care, Baker Trucks can cost their owners as little as $50 per year for maintenance and repair.
3. **Lowest Operating Cost.** Electric power is the cheapest power available for heavy duty industrial truck operation—even with cost of battery depreciation.
4. **Lowest Investment Cost**—when amortized over their many years of useful service. Most electric trucks are still going strong after 15 to 20 years of strenuous service.
5. **Maximum Safety.** Electric power is *safe* power—free from excessive heat, noxious fumes, and dangers of explosion or fire.
6. **Most Efficient Performance.** Smooth starting—powerful acceleration—more positive control—no gear shifting—these are some of the operating advantages of electric trucks.

## C THE CASE FOR BAKER INDUSTRIAL TRUCKS

1. **Complete Line** for every type of industrial truck handling system. In addition to standard Low-Lift, Hy-Lift, Fork, Crane, and Platform Trucks, Baker makes tractors and a wide variety of special trucks for unusual handling operations. For example, Baker makes an Articulated Fork Truck for operation in narrow aisles and congested areas.
2. **Baker Representatives** in all principal industrial centers are qualified material handling engineers, available for counsel on your material handling requirements. They will help you select the proper equipment for your needs.
3. **Baker Engineering and Service** are dedicated to the continuous operation of all Baker Trucks. Adequate stocks of spare parts are maintained to meet emergencies. Baker representatives are available for consultation and help at all times and factory engineers make periodic field trips throughout the country to insure satisfactory operation and to recommend proper truck care.
4. **Baker Motors** on all Baker Trucks are designed and built by Baker, to give greatest efficiency for their specific functions. Baker Travel Motors develop more horsepower and contain more copper and iron than any other motors of the same size.
5. **Baker Power Axle.** Careful selection of properly heat-treated steels, plus many exclusive design features, practically eliminate service failures and greatly reduce maintenance.
6. **Baker Duplex Compensating Suspension**—an exclusive Baker feature which holds power axle in alignment, and prevents twisting strains due to rough floor conditions from being transmitted to frame or steering rods.

These are a few of the advantages offered by Baker Electric Power Industrial Trucks. For further information, call in your nearest Baker representative, or write us direct.

*Member:*
*Electric Industrial Truck Association*

**BAKER INDUSTRIAL TRUCK DIVISION**
*of The Baker-Raulang Company*
2166 WEST 25th STREET • CLEVELAND, OHIO
*In Canada: Railway and Power Engineering Corporation, Ltd.*

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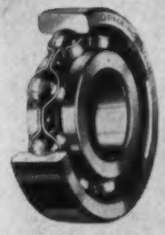
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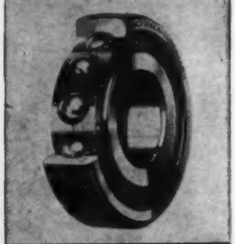
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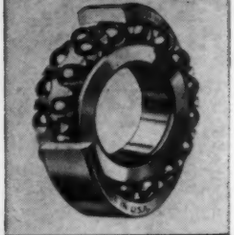
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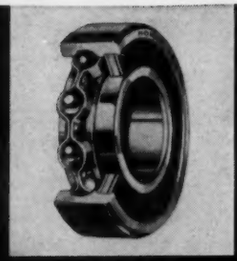
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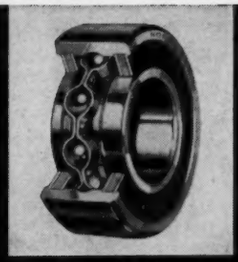
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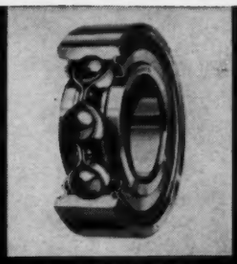
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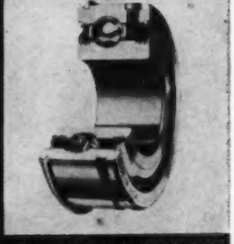
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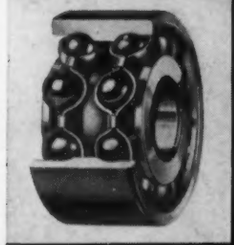
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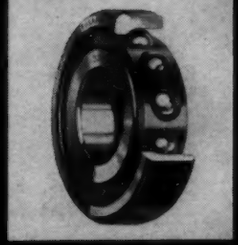
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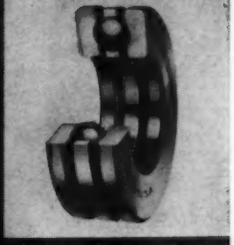
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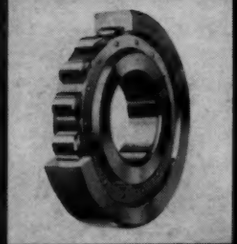
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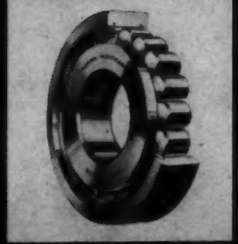
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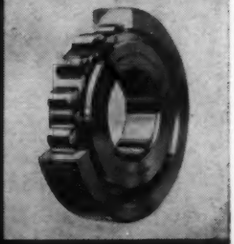
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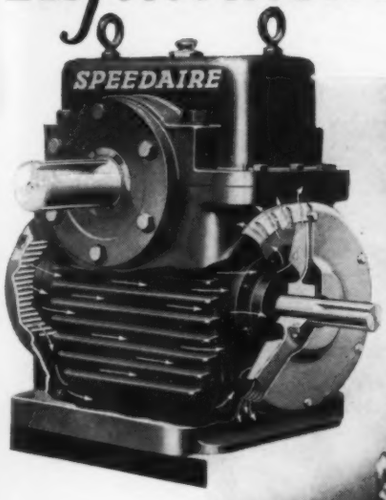


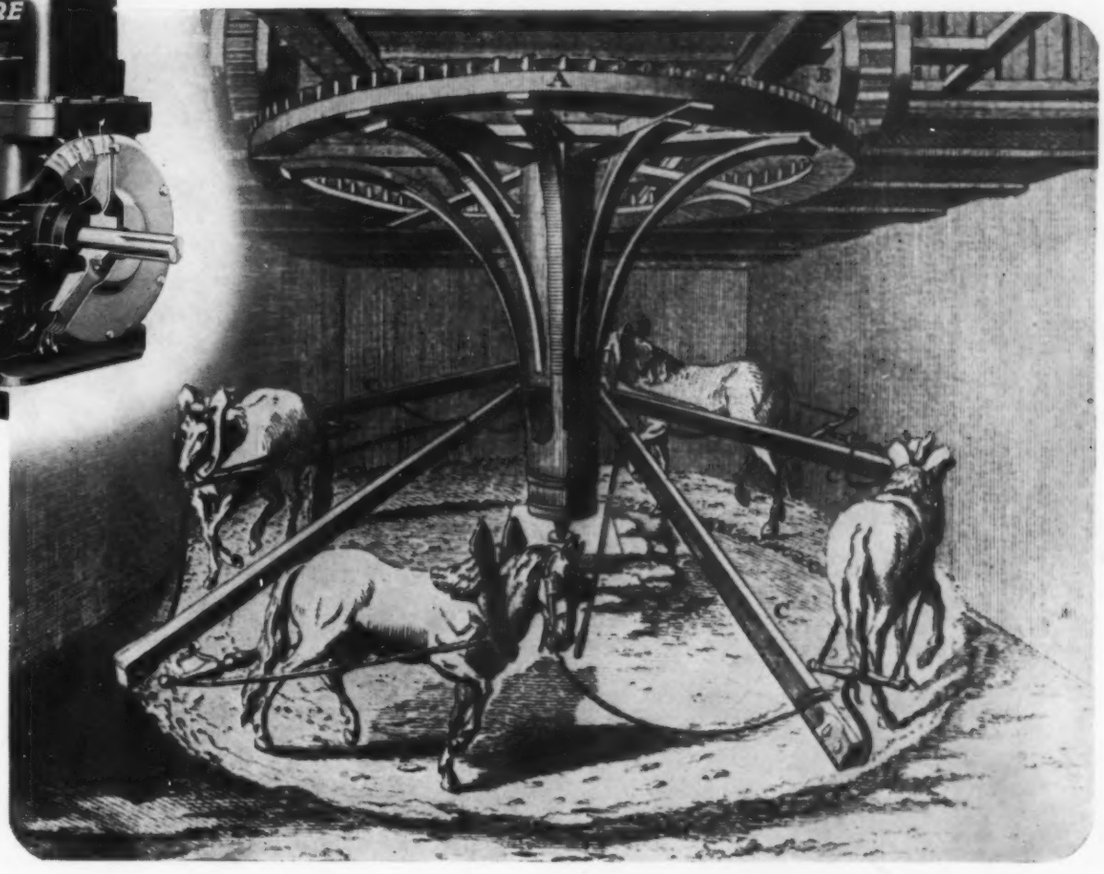

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